On the Occasion of 2500th NIRVANA Anniversary of
BHAGWAN MAHAVIRA

THEORY OF ATOM IN THE JAINA PHILOSOPHY

A Critical Study of the Jaina Theory
of PARAMANU PUDGALA in Light of
Modern Scientific Theory

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CONTENTS

INTRODUCTION

For ages the enigma of the physical universe has been pondered alike by religion (theology), philosophy and science The fundamental problems, no doubt, remained the same from one age to another, but the point of view from which they were attacked varied with the viewer as well as the age It would therefore be not surprising if the answers to the problem are found to be radically divergent Answers given by theology, for instance, are based mostly on dogmatic belief that we have knowledge, where in fact, we have ignorance Science on the other hand cannot answer many questions of great interest raised by inquisitive human mind 'Philosophy is intermediate between theology and science' says Sir Bertrand Russell "and it is the business of philosophy to study such problems in order that we do not become insensitive to many things of great value "[1]

India's philosophical culture is characterised by a sincerity of purpose and seriousness of outlook as well as freedom of thought which was unknown in the western countries State persecution and censorship of thought was conspicuous by its absence because Indians did not seek to make political capital out of their religious persuasion

At the same time, unlike West, Science has never been able to completely subjugate the religious sensitivities In India at least, mystery, ambiguity and transcendence remain as important as rationality, logic and sensible perception Here, man's personality is not entirely denatured by the scientific objectivity nor has mystery and sacredness been taken away

1 *History of Western Philosophy, Page 13*

by its rationality In short, science inspite of its spectacular achievements, did never become a new religion here as it in effect did in the West

Systematization of Jain philosophy is comparatively a recent event though it had its moorings in the canonical literature i e Agamas According to Jain belief the doctrines promulgated by Bhagvan Mahā vira whose 2500th Nirvana Anniversary is being celebrated this year are even more ancient and were preached by a succession of 23 Tirthankaras thousands of years before him The earliest Jain literature though not extant is much more ancient than Bhagvan Mahavir Commentaries on Āgamas and independent treatises by great savants between 8th to 12th centuries systematised and connected the divergent elements into logical doctrines remarkable for their originality, acuteness and subtlety

Jain philosophy does not swear by mysticism though it culminates in it But the mysticism is not the result of dogmatic faith Philosophical speculation is a necessary discipline of the mind for attenuating doubts But the ultimate truth cannot be realised by philosophical discipline alone The terminus of philosophy is the beginning of spiritual career The plenum of knowledge can be attained by the development of a superior power of vision which is not satisfied with the negative findings of reason and seeks infinite perfection 'The Jains are emphatic that omniscience is the condition as well the result of perfection and however much we may advance in our philosophical enquiry and scientific pursuit, which are not antagonistic in their aim inspite of their difference in method and lines of approach, it

cannot by itself unlock the mystery of ultimate reality and bring about the final consummation "[2]

[3]"Modern science has made tremendous progress during the last hundred years Few people have been more publicly admired than scientists, engineers and technologists Together they discovered the secrets of the microcosm and perfected the ways of controlling and tapping colossal stores of nuclear energy, they probed the vast spaces of the universe and pried into the mysteries of the macrocosm, discovered the mechanisms of heredity and compounded the miracle of modern medicine With utmost daring and immense resourcefulness, they capped their achievements by landing man on the moon to gather first hand knowledge of the earth's nearest celestial body

'Ironically this very age of unprecedented scientific progress has also become the dawn of a new age of doubts regarding the future benefits of bold new scientific ventures, to the human race because technological advances seem to accompany environmental ravages On the philosophical level there is a new mood of scepticism about the absolute objectivity and utter rationality of the scientific methods Says Harvard Biologist-Historian E I Mendelsohn Science as we know it has outlived its usefulness' There is a new fascination with the mystical and even irrational In the recent years there is a loud and insistent chorus for antiscience Declares Richard H Bube a professor of materials science and electrical engineering at Stanford 'One of the most pernicious falsehoods ever to be almost universally accepted is that the scientific method is the only reliable

2 From preface to *Jain Philosophy of Non-absolutism by* Prof Dr Satkari Mookerjee

3 *Time (Weekly Magazine)*

way to truth' Insisting that there is also 'spiritual knowledge and power' besides reason, Theodore Roszak pleads for a return of submerged religious sensitivities 'Here is a range of experience that we are screening out of our experience in the name of what we call knowledge' says Roszak The late psychologist Abraham Maslow said that we have learned to think of knowledge as verbal, rational, logical and sensible but transcendental experience is equally important."

And so, perhaps this is the most appropriate time to make an attempt to compare the findings of philosophical enquiry with the results of scientific pursuit "In the history of human thinking" says Werner Heisenberg, "new, interesting and the most fruitful developments frequently take place when two different lines of thought-lines having their roots in quite different parts of human culture, in different times, or different religious traditions-meet",[4] and mutually interact Synchronising the presentations of scientific facts with that of philosophical findings is, however, a very difficult task The writer may "either succeed in being intelligible by offering only superficial aspects of the problem and thus arousing in the reader the deceptive illusion of comprehension or give an account in such a fashion that the reader is unable to follow the exposition and becomes discouraged from reading any further "[5] I do not know whether I have been successful in making this presentation both readable and intelligble, the reader who honours me by perusing my humble effort has to decide this for himself I have derived much assistance from the following publications for compiling this monograph

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4 *Physics and Philosophy* p 161

5 Albert Einstein Foreword to *The Universe and Dr Einstein*

1) *One, two, three, Infinity* by George Gamow
2) *Jain Padartha Vijñāna Mem Pudgala* by Mohanlal Banthia
3) *History of Western Philosophy* by Sir Bertrand Russell
4) *Physics and Philosophy* by Werner Heisenberg
5) *Visva Prahelika* by Munisri Mahendrakumarji Dviteeya'
6) *Studies in Jain Philosophy* by Dr N M Tantia

I am extremely grateful to Acharya Shri Tulsi, who has been the main source of inspiration and but for his blessings, the present work would not have been accomplished

I am also grateful to Muni Shri Mahendrakumarji 'Dviteeya' (my son in worldly relation) for his valuable assistance

Bhagwan Mahāvira's 2500th Nirvāna Anniversary
13 November 1974
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CHAPTER I

ATOM IN MODERN SCIENCE

INTRODUCTORY

The world is composed of a multitude of things, partly animate and partly inanimate But the two orders of existence known in the modern times as physical and psychical, were not clearly distinguished by the early naive and primitive thought The recognition of the psychical as an order of existence distinct from the physical belongs to a later stage of intellectual development

The concept of matter has undergone a great number of changes in the history of human thinking Different interpretations have been given in different philosophical systems All these different meanings of the word are still present in our time as the word 'matter'

The problem of atom, the smallest indivisible unit of matter is one of the earliest as well as one of the most persistent in the whole range of philosophy of nature, as well as experimental sciences

When experimental sciences which deal directly with material substances and their properties, investigate the problem, it can do so only through a study of the infinite variety and mutability of the forms of matter Its fundamental task is the discovery of descriptive formulae which assist depiction and calculations of various processes and finding some natural laws, some unifying principles that can serve as a guide through immense field The philosophy of nature, on the other hand does not deal with the particular facts amassed by experiment but with the hypothesis used by experimental science for the co-ordination of those facts The goal of experimental science is the description of the facts while the

goal of philosophy is their interpretation The difference of aim is however not ultimate.

Physical science draws a marked distinction between the sensible things i e objects which are perceived by senses , and consciousness And this division of existence of two orders strongly dominates our thought about the universe The following points are generally agreed upon as the distinguishing marks between the two orders

A) Physical existence is purely material and is devoid of consciousness, whereas, psychical order possesses consciousness

B) Physical order is made up of events which conform rigidly to certain universal laws The elements of which it is composed always behave in the same surroundings in the same uniform way Whereas the sequence of events in psychical order is teleological (i e determined by reference to an end or purpose) that of the physical order is mechanical (i e determined by the principle of causality)

C) Every element of physical order fills a position in space and time and is therefore perceptible whereas consciousness is imperceptible by the senses

Thus we may say that the physical order comprises all sensible existence (i e existence of the same kind as that perceived by the senses whether actually so perceived or not) as an aggregate of events in time and space, linked together by the principle of causality and exhibiting conformity with the general law From this general characteristics of the physical order arise the fundamental problems of cosmology viz , the real nature of material existence and the ultimate significance of the distinction between the two orders

DEVELOPMENT OF ATOM FROM ANCIENT PHILOSOPHY TO MODERN SCIENCE

In this chapter we propose to review how the exceedingly primitive way of conceiving the nature of material existence developed stage by stage from the first epoch of Greek philosophy to the nuclear physics of modern times Our discussions, however, will necessarily be quite imperfect and elementary for more reasons than one Firstly, the facts of which some account must be taken are so numerous and complicated that they would require for their mastery something like an encyclopaedic acquaintance with the whole range of experimental sciences viz, physics, chemistry, etc Secondly, an adequate interpretation on the cosmological side would demand a familiarity with higher mathematics Thirdly, full discussion of the divergent views held by the different philosophers and scientists, would demand very much more space than we are at liberty to grant in this article All that we can hope to do here is to deal with the broad outline of the general principles

The early Greek philosophy from Thales to the Atomists in seeking the unifying principle in the universal mutability of all things, had formed the concept of cosmic matter, a universal substance, which experiences all these transformations, from which all individual things arise and into which they become again transformed This matter was partly identified with some specific natural element like water, air or fire

There is enormous difference between modern science and ancient Greek philosophy Since the time of Galileo (and Newton), modern science has been based upon a detailed study of nature and upon the postulate that only such statements should be made, as have been verified or at least can be verified by

experiments. The idea that one could single out some events from nature by an experiment, in order to study the details and to find out what is the constant law in the continuous change, did not occur to the Greek philosophers Therefore, modern science has from its very beginning stood upon a much more modest, but at the same time firmer, basis than the ancient philosophy Therefore, the statements of modern physics are in some way meant far more seriously than the statement of Greek philosophy When Plato says, for instance that the smallest particles of fire are tetrahedrons, it is not quite easy to comprehend what he really means

ATOM IN GREEK PHILOSOPHY

The idea of the smallest indivisible ultimate building blocks of matter first came up in connection with elaboration of the concepts of Matter, Being and Becoming which characterised the first epoch of Greek philosophy The fundamental question was 'what is the material cause of all things?' Simultaneously, there was a demand that this question be answered in conformity with reason, without resort to myths, mysticism or superstition

Greek philosophy and science which were not originally separate were born together at the beginning of the sixth century B C, with the first of the Milesian philosopher, Thales He took his view primarily from meteorological considerations and held that "WATER" is the material cause of all things "

Of all things, we know, WATER can take the most diverse shapes, it can take the form of ice and snow, it can change itself into vapour and can form clouds It seems to turn into earth where the rivers form their delta, and it can spring from the earth And to add to all this, wateris the condition—a must for life to exist

If there was such a fundamental substance at all, it was natural to think it to be of water as out of this all others are formed

Anaximander, second philosopher of the Milesian school and a pupil of Thales, did not accept water or any other known substance as the fundamental substance According to him the primary substance was infinite eternal and ageless and it encompassed the whole world This primary substance, according to him, was transformed into the various substances with which we are familiar and these were transformable into each other

Anaximenes, the last of the Milesian triad (500 B C) taught that AIR was the primary substance "The soul is air fire is rarefied air when condensed, air becomes first water, then earth and finally stone " Thus he introduced the idea that the process of condensation and rarefication caused the change in the primary substance The condensation of water vapour into clouds was an obvious example and of course the difference between water vapour and air was not known at that time

The Milesian school of thought is important not for what it achieved but for what it attempted The speculation of Thales Anaximander and Anaximenes are to be regarded as scientific hypothesis The next stage in Greek philosophy is more religious but less scientific

Heraclitus (500 B C) was a mystic of a peculiar kind He regarded FIRE as the basic element Everything like the flame in a fire is born by the death of something He taught that the world is at once one and many There is unity in the world but it is not unity forming the combination of the opposites The strife of the opposites is really a kind of

harmony and 'the opposite tension' of the opposites constitutes the unity of the one He believed in perpetual change That all things are in a constant state of flux, this flux being due to an everlasting conversion of matter into energy and energy into matter, everywhere over the vast stretches of the material universe

At this point let us pause for a while and compare the findings of the ancients with the modern Firstly, the problem whether the primary substance can be one of the known substances or must be something essentially different occurs in a somewhat different form in the most modern part of atomic physics The physicists today try to find a fundamental law of motion for matter from which all elementary particles and their properties can be derived mathematically This fundamental equation of motion may refer either to waves of a known type to proton and meson waves or to waves of an essentially different character which have nothing to do with any of the known waves of elementary particles In the first case it would mean that all other elementary particles can be reduced in some way to a few sorts of 'Fundamental' elementary particles In the second case all different elementary particles could be reduced to some universal substance which we may call energy or matter, but none of the different particles could be preferred to the others as being more fundamental The later view of course corresponds to the doctrine of Anaximander and in modern physics this view is perhaps the correct one

Next, Heraclitus holds that the change itself is the fundamental principle and is represented by FIRE as the basic element which is both matter and a moving force Modern physics is in some way extremely near

to the doctrines of Heraclitus If we replace the word 'fire' by the word 'energy' we can almost repeat his statement word for word from our modern point of view. Each manifestation of energy involves either matter in motion or a change in its physical state, which we designate as physical energy, a change in the chemical constitution of matter, which we know as chemical energy, or a combination of the two Physical energy can be converted into chemical energy and vice versa The chemical energy stored in the plant manifests itself by an increase in the plant as weight as compared with that of its original constituents Similarly, the release of the energy manifests itself through a loss in the total weight of the plants as substance Energy is, in fact, the substance from which all elementary particles, all atoms and therefore all things are made, and energy is that which moves Energy is a substance since its total amount does not change and that the elementary particles can actually be made from this substance is seen in many experiments on the creation of elementary particles Energy can be called the fundamental cause for all change in the world But comparison of Greek philosophy with the ideas of modern science will be discussed later

Parmenides (450 B C) denied the existence of empty space for logical reasons Since all change required empty space, as he assumed, he dismissed the change as an illusion Where Heraclitus maintained that everything changes, Parmenides retorted that nothing changes What the subsequent philosophy accepted from Parmenides was not the impossibility of all change but the indestructibility of substance

Empedocles (440 B C), younger contemporary of

Parmenides, changed for the first time from monism to a kind of pluralism He assumed four basic elements; Earth, Water, Air and Fire Each of these were everlasting but they could be mixed together in different proportions and separated to form the varieties of things and thus produce the changing complex substances that we find in the world. Here for the first time the idea is expressed that the mixture and separation of a few substances, which are fundamentally different, explains the infinite variety of things and events.

According to these views, the soil, for example, was a combination of earth substance and water substance closely mixed atom by atom. A plant growing from the soil combined earth and water atoms with the fire atoms coming from the rays of the sun to form composite molecules of wood substance The burning of dry wood from which the water element was gone, was viewed as decomposition or breaking up of wood molecule into the original fire atoms, which escape in the flame and the earth atoms which remain as the ashes.

Anaxagoras (462–422 B C) a contemporary of Empedocles took the next step towards the concept of atom He assumed an infinite variety of infinitely small seeds (not the four elements of Empedocles but innumerably many different seeds) which were mixed together and separated again to create multiplicity of things. the seeds may change in number and in relative position All seeds were in everything, only the proportions might change from one thing to another

THE ATOMISTS

The founders of atomism were two—LEUCIPPUS

and DEMOCRITUS. It is difficult to disentangle them because they are generally mentioned together

Democritus who was a contemporary of Socrates and who flourished about 420 B.C., took the final step towards the concept of atom, the indivisible smallest unit of matter His atom is eternal and indestructible but it has a finite size Thus the idea, of the elementary particle as the fundamental building block of the matter, was voiced for the first time in the history of western philosophy twenty three centuries ago [6]

The atoms of Democritus were all of the same substance but had different sizes and shapes. Each atom was eternally unchanging and in fact a Parmenidean one Each atom was impenetrable and indivisible because it contained no void Between atoms there was empty space or void through which they could move, collide with each other and occupy different positions, and may combine with each other sometimes But they had no other physical properties They had neither colour, nor smell nor taste The properties of matter which we perceive by our senses were supposed to be produced by the movements and positions of the atoms in space

Democritus is quoted to have said "A thing merely appears to have colour, it merely appears to be sweet or bitter Only atoms and empty space have a real existence"

The basic ideas of atomic theory were taken over and modified in part by the later Greek philosophers Epicurus (342–270 B C) followed Democritus in believing that the world consisted of atoms and void, but he did not believe, as Democritus did, that atoms were at all times completely controlled by natural laws

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6 The Jain Theory of *Paramāṇu* is more ancient See Chapter II

Plato (428–348 B.C) who was not an atomist himself combined ideas that were near to atomism with the doctrines of the Pythagorean school and the teachings of Empedocles. Pythagoreans had established the connection between religion and mathematics which ever since has exerted the strongest influence on human thought. There was also much mysticism in the doctrines of the Pythagorean school which for us is difficult to understand But by making mathematics a part of their religion they touched upon an essential point in the development of human thinking

Plato knew of the discovery of the regular solids made by the Pythagoreans and of the possibility of combining them with the elements of Empedocles He compared the smallest parts of the element earth with the cube, of air with the octahedron, of fire with the tetrahedron and of water with the icosehedron and so on The common characteristics of the regular solids which represent the four elements and the atoms of Democritus was that both were indestructible But the smallest parts of matter were not the fundamental Beings, as in the philosophy of Democritus but were mathematical forms Here it is quite evident that the form is more important than the substance of which it is the form

After this short survey of Greek philosophy we may come back to modern physics and compare our modern views on the atom with this ancient development. Historically the word 'atom' in modern physics and chemistry was referred to the wrong object, during the revival of science in the seventeenth century, since the smallest particles belonging to what is called a chemical element are still rather complicated systems of smaller units These smaller

units are now-a-days called elementary particles and it is obvious that if anything in modern physics should be compared with the atoms of Democritus it should be the elementary particles like proton, neutron, electron, meson, etc

Metaphysically, the atom of Democritus is rather an abstract piece of matter since it is deprived of the qualities of colour, smell, taste, etc., which are explained by the motion and arrangement of atoms. But his atom has the primary quality of "Being" and of extension in space, of shape and motion It would have been difficult to speak about the atom if latter qualities had also been taken away from it

Elementary particle of modern science has also no colour, no smell nor taste and in this respect resembles the atom of the Greek philosophy Moreover elementary particles of modern physics are as much abstract as the atom of Greek All atoms of Democritus consist of the same substance. The atoms of Democritus are eternal, indestructible units of matter. The elementary particles of modern physics are certainly not eternal and indestructible units of matter, they can actually be transformed into each other. All particles are made of same substance. energy.

Carrying the comparison from metaphysical point of view to familiar objects, we now know that air is not a simple element as the ancients thought but is a mixture of nitrogen, oxygen, carbon dioxide and water vapour Let us take another example illustrating differences between ancient and modern views on chemical transformations. We know that different metals are obtained by processing corresponding ores in furnaces at high temperatures. The ancient scientists believed that ores were made from the earth

substance as other rocks. So, when they obtained strong shining substances from these ores, they explained the transformation by saying that the metal was formed by a union of earth and fire. The different qualities of different metals were accounted by saying that different proportions of earth and fire atoms went into their formation. Thus, gold contained more fire than iron.

Reasoning that if fire atoms were added to iron or copper it would turn into gold, the alchemists of Middle Ages spent much time to make synthetic gold from cheaper metals. The fallacy of their theory and practice lay in their belief that metals were composite rather than elementary substances. The transformation of iron ore into metallic iron in the blast furnace is not due to a union of atoms as ancients believed, but quite the reverse Most metallic ores are oxides and the process of making metal is the separation of oxygen atoms from the molecules of the oxide, leaving the atoms of pure metal On the other hand the rust which appears on the surface of iron objects due to moisture is not earth substance left behind after the escape of fire atoms from the iron substance but the formation of iron oxide resulting from the union of iron atoms and oxygen atoms from the water or air

Thus, whereas, an ancient scientist would express the processing of iron ore by the formula,

(a) Earth atom + fire atom = Iron atom
and the rusting of iron by.

(b) Iron = Earth + Fire
(rust)

(b) The modern chemist would express the same by.

(a) $FeO_2 = Fe + O_2$

(b) $Fe + O_2 = FeO_2$

From the above discussion it is obvious that ancient concepts of the structure of matter and the nature of chemical transformations were basically correct Their error lay in the misconception of what was composite and what was the elementary substance In fact none of the four elements listed by Empedocles is really elementary Air is a mixture of oxygen, nitrogen and other gases, water is a compound of hydrogen and oxygen earth has a very complex composition and fire atoms do not exist at all [7]

Actually there exists in nature not four but 92 different chemical elements i e 92 different kinds of atoms While some of these elements such as oxygen, nitrogen, carbon, etc , are rather abundant others are very rare In addition to 92 natural elements modern science has succeeded in making several entirely new elements artificially [8] Combining among themselves in various proportions, the atoms of these basic elements form the unlimited number of various substances, some simple and common such as water, others complex chemical materials such as sugar, starch, cellulose

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7 As we have remarked earlier the word fire can be replaced by energy but the idea of fire atoms itself was also partially revived in Quantum theory of light

8 *The following elements have been artificially made by man*

Atomic No	Name	Symbol
93	NEPTUNIUM	Np
94	PLUTONIUM	Pu
95	AMERICIUM	Am
96	CURIUM	Cm
97	BERKELIUM	Bk
98	CALIFORNIUM	Cf
99	EINSTENIUM	Ei

STRUCTURE OF ATOMS

The first real step forward in an understanding of the various chemical and physical properties of different items was taken when it was accepted that atoms were not simple indivisible particles of various shapes and sizes, but on the contrary rather complex mechanisms with a number of independent parts in motion

In 1904 famous British Physicist J.J Thomson successfully proved that the atoms of various chemical elements consist of positively and negatively charged components They are held together by the forces of electric attraction He called the negatively charged particles Electrons a large number of which were floating in the interior of a mass with a uniformly distributed positive charge The atom on the whole is electrically neutral because the total charge of all negative particles equals the total positive charge The electrons were assumed to be bound comparatively loosely to the body of the atom and one or several of them could be removed by the process of ionisation Thomson was able to estimate

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100	FERMIUM	Fm
101	MENDELEYIUM	Md
102	NOBELIUM	No
103	LAWRENCIUM	Lw

Lawrencium was discovered at the University of California in early 1961 The above elements together with the following natural elements are called actinide elements or elements of actinium series

Atomic No	Name	Symbol
89	ACTINIUM	Ac
90	THORIUM	Th
91	PROCTACTINIUM	Po
92	URANIUM	U

the mass of an electron which turned out to be very very small indeed According to his estimate, the mass of an whole hydrogen atom is 1840 times the mass of an electron This indicates that the main portion of atomic mass is contained in its positively charged component.

Thomson was, however, very far from the truth concerning the uniform distribution of the positive charge through the body of the atom In 1911, Rutherford showed that almost the entire mass as well as the positive charge of the atoms is concentrated in an extremely small nucleus located in the very centre of the atom As the result of his famous experiments on the scattering of the so-called "alpha particles in their passage through matter, Rutherford came to the suprising conclusion that both, the incident alpha particle and the positively charged part of the atom, are thousands of times smaller than the atom itself Thus the originally widespread positive charge of Thomson's atom shrunk into a tiny atomic nucleus in the centre of the atom, while the electrons rotated outside Thus the picture of the atom began to look more like a miniature solar system—nucleus being the sun and electrons being the planets

The diameter of the atom is 100,000 times greater than the diameter of the nucleus while its volume is 500,000 billion times the volume of the nucleus The atomic nucleus contains 99 97 percent[9] of the total atomic mass and the distance between the electrons exceeds their diameter by several thousand times The electric attraction forces between the nucleus and the electrons obey the mathematical law of inverse square i e the forces are inversely propor-

9 99.87% of the total mass of the solar system is concentrated in the sun

tional to the square of the distance between them and the electrons describe the circular and elliptical trajectories around the nucleus It can thus be seen that most of the matter in the universe is concentrated in the nuclei of the atoms The density of the matter in the nucleus is such that a paise would weigh 600 million tons if its atoms were as tightly packed as the particles in the nucleus

It was found by Rutherford that in the natural sequence of elements arranged in the order of increasing weights, there is a consistent increase of one atomic electron in each element in the sequence Thus an atom of hydrogen has one electron, an atom of helium 2, lithium 3, berillium 4, and so on upto the heaviest natural element, uranium which has altogether 92 electrons

The numerical designation of an atom is usually known as its atomic number and coincides with its positional number in the atomic table Thus all the physical and chemical properties of any given element can be characterised simply by one figure giving the number of electrons rotating around the central nucleus

It was noticed that some of the properties of the elements begin to repeat themselves after a definite number of steps when arranged in a natural sequence Since each step along the sequence of elements corresponds to one additional electron, the observed periodicity must be due to the recurrent formation of certain stable configuration of atomic electrons, or "electronic shells" It has been established that the first completed shell consists of 2 electrons, the next two shells of 8 electrons each and all the following shells of 18 each[10]

We can now, having the picture of an atom, turn

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10 See Appendix

our attention to the nature of forces which bind together the atoms of different elements into complex molecules of innumerable chemical compounds The chemical bond between the neighbouring atoms in a molecule is due to the interaction of the electronic shells and the forces involved are comparatively small The distinction between the atomic nuclei and the electronic shells of different elements at once gives a proper explanation of the various physical and chemical properties of the elements and also of the fact that they are the last units of matter The chemical properties of atom are however controlled by the nucleus If one wants to change the chemical properties of an atom, one has to change the nucleus and this requires energies about a million times greater

ELEMENTARY PARTICLES

Atoms of all material elements are complicated mechanical systems with a number of electrons rotating round the central nucleus Are these atoms the ultimate units of matter? Can we sub-divide them still further into smaller and simple particles? Would it be possible to reduce all different atoms to perhaps a few really simple particles?

In the middle of the last century, William Prout, an English chemist put forth a hypothesis that the atoms of all elements are made up of various numbers of hydrogen atoms This hypothesis was based on the fact that the atomic weights of various elements were in most cases very nearly exact multiples of that of hydrogen Thus atoms of oxygen which are sixteen times heavier than those of hydrogen, must be composed of 16 hydrogen atoms somehow stuck together But the facts as found at that time were

unfavourable to the acceptance of this bold hypothesis Isotopes were not discovered and the chemical atomic weight of chlorine, for instance, being 35 5 was in direct contradiction to Prout's hypothesis He died without ever learning how right he actually was

In the year 1919 the British physicist F W Aston discovered that ordinary chlorine was actually a mixture of two different kinds of chlorine possessing identical chemical properties but having different atomic weights 35 & 37. Further study revealed the striking fact that a mixture of several components identical in chemical properties but differing in atomic weights made up most of the elements They were called isotopes Prout's forgotten hypothesis was given a new life and was reformulated by saying that nuclei of various atoms are composed of various number of hydrogen nuclei called protons

Actually the nuclei of various elements are composed of protons as well as neutrons which are electrically neutral and not positively charged like protons The existence of neutrons was suggested by Rutherford in 1920 but they were found experimentally only in 1932

Thus, the nucleus of an oxygen atom which is the eighth element in the atomic table and has 16 units of mass and 8 units of charge must be composed of 8 protons and 8 neutrons whereas the heavy nucleus of uranium, atomic weight 238 atomic number 92 is formed by 92 protons and 146 neutrons An important fact to keep constantly in mind about protons and neutrons is that the two are interchangeable A proton, under certain conditions, loses its positive charge by emitting a positive electron (positron) and thus becomes a neutron Similarly, a neutron when agitated emits a negative electron and becomes a

proton As we shall see, the latter process is taken advantage of in the transmutations of non-fissionable uranium into plutonium and of chromium into fissionable uranium 233 The transmutations of all other elements—age old dream of alchemists—is made possible by the interchangeability of protons into neutrons and vice versa Protons and neutrons are, thus, two electrical states of the same basic principle called nucleon

The atoms of the elements have twins, triplets, etc, known as isotopes The nuclei of these twins etc, all contain the same number of protons and hence all the same chemical properties They differ, however, in the number of neutrons in their nuclei and hence have different atomic weights For example, an ordinary hydrogen atom has nucleus of one proton The isotope of hydrogen, deuterium, has one proton plus one neutron in its nucleus It is thus twice as heavy as ordinary hydrogen.

We may now say that different combinations of only two types of basic particles result in the infinite variety of the material world (1) electrons with a negative electric charge and negligible mass and (2) nucleons which can either be neutral or carry a positive charge

However, this list of basic particles is obviously incomplete For if electron represents a negative free charge, why can't there be a positive free charge also? Similarly why a neutron cannot acquire a negative charge and become a negative proton?

Actually positive electrons called positrons have been discovered to exist in nature and though experimental science has not yet succeeded in detecting negative protons, there is a certain possibility that they also exist Since two equal and opposite charges

of electricity, if put together, will cancel each other if a positron encounters an electron, the two will cease to exist as individual particles This process of mutual annihilation creates an intensive electro-magnetic radiation called gamma rays which carry away the original energy of the two particles Conversely, a pair of a positron and electron is created as a result of strong gamma radiations at the cost of the energy supplied by these rays These processes of mutual annhilation and pair formation confirm that the matter and energy are basically the same substance

Another kind of elementary particle called neutrinos have the merit of actually participating in various observable physical processes These particles carry no electric charge and their mass does not exceed the mass of an ordinary electron Such chargeless light particles could'not be noticed by any existing physical apparatus Consequently they escaped from observation and were noticed only because of the deficit of energy which they carried away during what is known as beta-decay process

We can now make a complete list of the elementary particles participating in the structure of the material universe

First of all we have nucleons which represent the basic material particles They are either neutral or positively charged Plausibility of negatively charged nucleons is not entirely ruled out though they are not detected so far

Then we have the electrons and positrons representing the free charges of negative and positive electricity respectively

There are also the mysterious nutrinos which carry no electric charge and are presumably lighter than electrons

Finally there are the electromagnetic waves which account for the propagation of electromagnetic forces through empty space

All these fundamental constituents of the physical world are independent and can combine in various ways Thus a neutron can become a proton by emitting an electron and a neutrino, and a proton can revert to be a neutron by emitting a positron and neutrino Two electrons with opposite charges can be transformed into electromagnetic radiation or can be formed from the radiation Finally the neutrinos can combine with electrons forming the unstable units observed in the cosmic rays and known as mesons

A question which may be asked at this stage is "Is it right to assume that these nucleons etc, are really elementary and cannot be sub-divided into still smaller constituent parts? Wasn't it assumed only less than a century ago that the atoms were indivisible? Yet what a complicated picture they present today?" The answer is that, although there is of course no way to predict the future development of the science of matter, we have now much sounder reasons for believing that our elementary particles are actually the basic units and cannot be sub-divided further Whereas allegedly indivisible atoms were known to show a great variety of rather complicated chemical and other properties, the properties of elementary particles of modern physics are extremely simple In fact they can be compared in their simplicity to the properties of geometrical points [11]

11 This can be illustrated by a match stick A large amount of energy is waiting to be set free but the match will not burn unless heated by friction

NUCLEUS—THE HEART OF ATOM

Let us now turn to a more detailed study of the nucleus-the heart of every atom Whereas the structure of the outer body of the atom can be to a certain extent compared to a miniature planetary system, the structure of the nucleus itself presents an entirely different picture It is clear first of all that the forces holding nucleus together are not electrical, since the protons are all positively charged, thus repelling each other The electrical repulsion force in the nucleus, known as the coulomb force, varies inversely as the square of the distance separating the positively charged particles Prof E Soddy, has figured out that two grams of protons placed at the opposite poles of the earth would repel each other with a force of twenty-six tons

Therefore there must exist, between the constituent parts of the nucleus, forces of some other kind, which must be many times greater than the coulomb force These are generally known as "cohesive forces" and are similar to those encountered in ordinary liquids causing the phenomenon of surface tension In the atomic nuclei we have similar forces of much greater magnitudes acting as the cosmic cement which prevents the breaking up of the nucleus under the action of electric repulsion between the protons Thus, if we assume the nuclei of different elements to be droplets of a universal "nuclear fluid"and the density of such a fluid will be 24×10^{3} times that of the water Its surface tension forces will be about 10^{18} times larger than those of water

It must be remembered that all protons in the nuclei are positively charged and the electric forces of repulsion between them try to disrupt the nucleus into its constituents These electric forces are coun-

teracted by cohesive forces which tend to keep it unified This is the secret of the instability of some of the nuclei If the forces of electric repulsion predominate, the nucleus will have a tendency to break-up into two or more parts, the process being known as fission On the contrary if the cohesive forces hold the upper hand not only the nucleus will never break by itself, but will also have a tendency to fuse with other nuclei coming into its contact It is now established that the electric repulsion forces prevail in all heavier nuclei, while the cohesive forces hold the upper hand in the lighter elements approximately upto silver Each proton and neutron in the elements weighs less than it does in the free state, the loss of weight being equal to the energy binding the nucleons This loss becoming progressively greater for the elements in the first half of the atomic table, reaching its maximum in the nucleus of silver After that the loss gets progressively smaller Since each loss of mass manifests itself by the release of energy, it can be seen that to obtain energy from the atoms nucleus requires either the fusion of two elements in the first half of the table or the fission of an element in the second half

However because of the state of metastability, neither the fission nor fusion would occur normally unless something was done to start the process[12] And the process of starting a nuclear reaction is extremely difficult because it needs very high activation energies

ATOMIC NUCLEAR ENERGY

We have already observed that matter and energy are two different manifestations of one and the same cosmic entity, instead of being two different entities

12. Please see Chapter III for discussion on this point.

Matter instead of being immutable was energy in a frozen state, while, conversely, energy was matter in a fluid state. The liberation of energy in any form —chemical, electrical or nuclear— involves the loss of an equivalent amount of mass

It is well known that most chemical reactions liberate energy, simplest instance being burning of coal The chemical union in this case, is that of carbon and oxygen in the form of molecular fusion When 3000 tons of coal are burnt to ashes, the residual ashes and the gaseous products weigh one gram less than 3000 tons, that is, one three-billionth part of the original mass will have been converted into energy

Thus oxygen (o) + carbon (c) = Carbon monoxide (co) + energy

This reaction would give 92 units of energy per gram of mixture If instead of molecular fusion of these two atomic species we have a nuclear fusion between their nuclei ${}_6C^{12} + {}_8O^{16} = {}_{14}Si^{28}$ + energy—the energy liberated per gram of mixture will be 14×10^9 Units, i e 15,00,000 times as great In the liberation of chemical energy by the burning of coal, the energy comes from a very small mass i e loss of mass resulting from the rearrangement of the electrons on the surface of atoms The nuclei of the carbon atoms are not involved in any way, remaining exactly the same as before The amount of mass lost by the surface electrons is one thirteenth of one millionth of one percent On the other hand nuclear energy involves vital changes in the atomic nucleus itself, with a consequent loss of as high as one tenth to nearly eight tenths of one percent in the original mass of the nucleus This means that from one to nearly eight grams per thousand grams are liberated

in the form of energy, as compared with only one gram in three billion grams liberated in the burning of coal In other words the amount of nuclear energy liberated in the transmutation of atomic nuclei is from 3,000,000 to 24,000,000 times as great as the chemical energy released by the burning of an equal amount of coal, whereas most chemical reactions would take place easily at temperatures of a few hundred degrees, corresponding nuclear transformation would not even start before the temperature reached many million degrees

Nuclear energy can be liberated by two diametrically opposite methods One is fission—the splitting of the nuclei of the heaviest chemical elements into two uneven fragments consisting of nuclei of two lighter elements The other is fusion—combining or fusing two nuclei of the lightest elements into one nucleus of a heavier element In both methods the resulting elements are lighter than the original nuclei The loss of mass in each case manifests itself in the release of enormous amounts of nuclear energy

75 years ago Bacquere's discovery of radio activity indicated that a break up process of nucleus can really take place Atoms of heaviest element uranium (and thorium) spontaneously emitted highly penetrating radiations (similar to X-rays) This process of slow spontaneous decay of the atoms of the so called radio active elements consists in emitting a small segment of its nucleus known as alpha particles and internal electric adjustment followed by emission of two electrons A series of emission continue until we come finally to the nucleus of the lead atom

Theoretically speaking all elements heavier than silver are radio active and subject to the process of

decay But the spontaneous decay is so slow–say one or two atoms in a gram of gold or mercury in many centuries compared to several thousand per second per gram in uranium—that the most sensitive physical instrument cannot record it

The discovery of radio activity proved the complexity of nuclear structure beyond any doubt and paved the way for artificial nuclear transformations Earlier, bombardment of the nuclei by artificially accelerated charged particles such as alpha, protons, etc, was the method employed for nuclear transformations But the electric charges carried by such particles caused them to lose much of its kinetic energy while passing through the atomic bodies and prevented them from coming sufficiently close to nuclei of the bombarded material The bullets to be used for more efficient bombardment are neutrons which because they do not have an electric charge, can penetrate the heavily fortified electrical wall surrounding the positively charged nuclei Just as coal fire needs oxygen to keep it going,a nuclear fire needs the neutrons to maintain it But uncharged projectiles viz, neutrons are not easily available in free form as they are tightly locked up within the nuclei of atoms and recaptured as soon as they are kicked out There is only one way to sustain the nuclear reaction and that is to create a self-multiplication process i e each bombarding neutron must liberate more than one other neutron which in their turn would act as bullets

Late in 1938 Rahn and Strassman discovered that atomic energy can be released through the fission process of uranium nuclei Like the two pieces of a broken spring, the two halves of a broken heavy nucleus begin their existence in a state of violent-

vibrations Before coming to rest, each of the fragments emits a neutron.

It must be remembered that, although the neutrons are much more effective nuclear projectiles than the charged particles, their effectiveness in producing the fission is, however, not cent per cent. The important condition for a sustained nuclear transformation is progressive neutron production or a chain reaction for which it is necessary that a hundred neutrons entering the substance would release many more than a hundred neutrons

There are two types of chain reactions Controlled and uncontrolled The controlled reaction is analogous to the burning of petrol in automobile engine The atom splitting bullets—the neutrons—are first slowed down from speeds of more than ten thousand miles per second to less than one mile per second by being made to pass through a moderator before they reach the atoms at which they are aimed Thus the liberation of neutrons is under complete control and acts as a slow but steady nuclear fire

The uncontrolled chain reaction is one in which there is no moderator—and no neutron absorbers It is analogous to the dropping of a match in a petrol tank In the controlled chain reaction the fast neutrons with nothing to slow them down or to devour them, build up by the trillion and quadrillion in a fraction of a millionth of a second This leads to the splitting of a corresponding number of atoms, resulting in the release of unbelievable quantities of nuclear energy at a tremendously explosive rate

It can be concluded from the general theory of nuclear structure that the fission effectiveness of neutrons increases with the increasing atomic weight of the element in question Thus, the fission of

uranium nuclei gives on the average a cent percent result; plutonium, a still heavier element would give a better result. If with each new generation the number of neutrons grow by, say, about 50 percent, there will be enough of them to attack and break-up any single nucleus of the material This is called the progressive branch chain reaction and the substance in which such a reaction will take place is called fissionable substance Among all the variety of nuclear species existing in nature, there is only one type of nuclei to which such reaction is possible These are the nuclei of the famous isotope of uranium, U-235, the only natural fissionable substance

U-235 does not, however, exist in nature in a pure form and is always found to be strongly diluted by the heavier unfissionable isotope of uranium U-238, (0 7 percent of U-235 and 99 3 percent of U-238), which hinders the progressive chain reaction in natural uranium Two methods are adopted to successfully utilise the atomic energy of U-235· (1) the straight forward separation of the two isotopes and (2) artificial reduction of the distributing action of the heavier isotope by the use of moderators

Other fissionable substances, not existing in nature, have been artificially built An artificial element which is known as Plutonium has the atomic number 94 and is even more fissionable than U 235 It is obtained by transforming the nucleus of natural uranium

Another artificial fissionable substance U-233 is obtained by similar transformation of the nuclei of natural radio active element Thorium (Th-232). In fact, it is possible, in principle at any rate to turn the entire supply of natural uranium and thorium into fissionable products which can be used as concen-

trated sources of nuclear energy

ATOM IN WAR

The requirement to start the fission process of U-235 and also the two man-made elements mentioned above (all these being known as nuclear fuels), is simple All that is necessary for the spontaneous combustion, to use a familiar phrase, of any one of the three atomic fuels, is to assemble a lump of a certain weight known as critical mass which is between ten and thirty kilograms This would mean that a lump of any of the three atomic fuels weighing ten or thirty kilograms (exact mass is a secret) would explode automatically and release an explosive force of 20 million times greater than that of TNT, (on an equal weight basis) Such a spontaneous combustion destroyed Hiroshima and Nagasaki on 6th & 9th August 1945 In a conventional A-bomb a critical mass is assembled by a timing mechanism that brings together let us say one-tenth and nine-tenths of a critical mass in the last split second

Long before it was discovered that vast amounts of energy could be liberated by the fission of the nuclear of U-235, scientists had known that fusion of four atoms of hydrogen into one atom of helium would release enormous amounts of energy In 1938 slightly before the discovery of uranium fission was annexed in Germany, Dr Bethe had published his famous hypothesis about the fusion of four hydrogen atoms to form helium in the sun This provided the first satisfactory explanation of the mechanism that enables the sun to radiate away staggering amounts of energy in space every second While Dr Bethe was the first to work out the fine details of the process of hydrogen fusion as source of the sun's radiance, Prof

F W Aston, British Nobel Prize winner and other scientists indicated the possibility more than 20 years ago We shall examine the solar process in brief a little later

Deuterium, popularly known as heavy hydrogen, is an isotope of hydrogen having double the weight of common hydrogen It was found to exist in nature constituting one five-thousandth part of the earth's waters Water containing two deuterium atoms in place of the two atoms of common hydrogen is called heavy water

The most startling fact discovered about deuterium was that it would become explosive at a temperature of the order of 50 000,000 degrees centigrade Explosive of an A-bomb would generate such high temperatures on earth and such an explosion would then act as a trigger for the hydrogen bombs

The basic difference between the fission bomb and the fusion bomb is the size The fact that as soon as a critical mass is assembled the fissionable atomic fuel explodes puts a definite limit to the amount of material that can be used in an A-bomb But an H-bomb with a thousand times the power of the A-bomb can be built by incorporating deuterium in the A-bomb Since deuterium is not limited to critical mass a thousand times the amount of the U-235 can be incorporated in an A-bomb where it would remain quiescent until the explosion of the A-bomb triggers the super explosion

Fission and fusion, however, are also common in everyday phenomenon that occur any time you burn anything Both are essential whenever energy is released, whether it is the chemical energy from coal or the atomic energy from nuclei of uranium or deuterium For example when you light a cigarette,

the first fission and fusion occurs in the lighting of the match, the cellulose in the match being fissioned into its component atoms of carbon and hydrogen These atoms are then fusioned with the oxygen of the air The same thing happens when the tobacco catches fire In each case the fusion with oxygen makes possible the fission of the cellulose

It is a scientific fact that man now has at his disposal means that not only can wipe out all life on earth, but also make the earth itself unfit for life for many generations to come Here we have indeed what is probably the greatest example of irony in man's history The very process in the sun that made life possible on earth and is responsible for its being maintained here, can now be used by man to wipe out that very life and to ruin the earth for good In both, fission and fusion, only a very small fraction of the mass of the protons and neutrons in the nuclei of the atoms used is liberated in the form of energy, while 99 3 to 99 9 percent of the substance remain in the form of matter

Scientists are even now engaged in finding means of converting 100 percent of the matter into energy i e complete annihilation of matter by the conversion of the entire mass of protons and neutrons into energy instead of only 0 4 to 0 7 percent And while the total conversion of protons and neutrons still seems speculative, we already know that such a process actually does take place in the realm of the electron This is the phenomenon of the mutual annihilation of a positive electron (positron) and a negative electron, achieved numerous times on a small scale in the láboratory In this process the entire mass of the two particles is converted into energy Luckily each positron must be individually

produced, since there are hardly any positrons in our part of the universe But suppose a new process that would release positrons in large numbers is found, just as the process of liberating large number of neutrons was found Such an eventuality, by no means beyond the realm of the possible would open potentialities of horror alongside which those of the hydrogen bomb would be puny For any process that would release a large number of positrons in the atmosphere, in a chain reaction similar to the one now liberating neutrons, may enevelope the whole earth in one deadly flash of radio active lightning that would instantly kill all life And although this is admittedly purely speculative, no one dare say that such a discovery will not be made, not when one remembers how remote and unlikely a process such as fission seemed to be just before it was made

JOURNEY INTO THE ORIGIN OF MATTER— *ATOM FOR PEACE*

We have completed the review of the development of atom over a period of more than 2500 years It would, however, be highly improper to close the chapter with a sense of utter doom which the above paragraph may forebode Enormous progress has also been made in the direction of utilising nuclear energy for the benefit of mankind, and it is our duty to give the reader a glimpse of the nuclear research and development work in which some tens of thousands scientists are all over the world today

Nuclear physics is now also known as elementary particle physics It is one of the fundamental sciences and like the Greek philosophers 2000 years ago, it asks the question what is the origin of matter? Its objective is to deepen man's understanding of the structure of matter

At atomic research centers in the United States of America, Russia, the United Kingdom, France, the Federal Republic of Germany and International Centre at Geneva, thousands of research teams are engaged in probing the heart of the atom We have already learned how to create secondary cosmic-ray particles of relatively low energies (350,000 electron-volts) with our giant Cyclotrons The creation of these particles known as mesons, which are believed to be the cosmic cement responsible for the nuclear forces, represent the actual conversion of energy into matter This is the exact reverse of the process taking place in fission and fusion, in which, we have seen matter is converted into energy And we are now about to complete multi-billion-volt atom smashers that will hurl atomic bullets of energies of from three to ten billion volts at the nuclei of atoms With these gigantic machines, known as the cosmotron (at the Brookhaven National Laboratory of the Atomic Energy Commission) and the bevatron (at the University of California) we shall be able to smash nuclei into their individual component protons and neutrons and thus get a much more intimate glimpse of the forces that hold the nuclei together

We have also learnt to create protons by machines called proton-synchrotons Any advance into the sub-nuclear world, however, would be impossible without machines known as accelerators These are for experiments in high energy physics to accelerate electrons and protons to high energies All accelerators operate on the same principle of raising electrically charged particles to high velocities by means of electrical fields

Protons generated in an ion source are first of all accelerated to an energy of 50 million electron volts

(Mev) by an electric field in a linear accelerator This energy corresponds approximately to a proton velocity of one-third the speed of light i e 100,000 km/s The protons are then accelerated further in a 200-meter diameter circular path by several radio frequency accelerator sections arranged round the periphery After about 500,000 orbits they reach a final speed which corresponds to 99 94% of the speed of light i e about 300,000 km s At this velocity the protons would cover the distance from the earth to the moon in approximately one second Through this process the rest mass of the protons is increased by a factor of 30

Research work in the sub-nuclear world is based on a law of nature that the smaller the dimensions of the particles to be studied, the higher must be the energies of the beams serving as a probe By way of comparison consider the forces that hold the nucleus of an atom together The binding energy of a proton in a nucleus is about 8 Mev In order to learn something about the structure of the nuclei, one needs energies about 100 times greater than this But to carry out research into the structure of proton or neutron, one requires energies 1000 times greater i.e of the order of one thousand million electron volts Elementary particle physics is, therefore, sometimes called high energy physics

To conclude this section let us reproduce what Dr Jentschke[13] has said in a recent interview [14]

13 Dr Willibald Karl Jentschke is the Director General of European Organisation for Nuclear Research (called CERN) which is half in French soil and half in Swiss soil Twelve nations have joined hand in peaceful research working to a convention that outlaw military aims

14 Published in *Siemens Review* June 1971

"Of fundamental imporiance is a knowledge of the character of the forces and interactions occuring in nature. The problems which are of current interest in high energy physics are

"The search for new particles Of considerable importance is the search for a particle–the boson.

"A further question that must be clarified is whether particles with magnetic charges exist, i.e so called magnetic monopoles

"Finally, we would like to know more about the dynamics of elementary particle processes and the structure of the particles themselves For instance, what is the explanation for the phenomenon of the invalidity of the law of time reversal in the case of K-meson decay?

"New experiments indicate that the nucleons probably contain punctiform sub-structures How is that to be interpreted? For, sometime now we have suspected the existance of a minute length to which our normal conceptions of space and time no longer apply, specially with regard to physical causality "

FUTURE FIELD OF RESEARCH

If we look at micro-structures as known to us so far from particle physics, they appear to be extremely complicated It is of course true that attempts have been made here and there to set up theoretical models However, many keys must still be found for the same to a comprehensive understanding of the origin of matter So far every advance to higher accelerator energy levels has brought new findings and some surprises It could perhaps be that knowledge of three basic buildings blocks would suffice to clarify the world of elementary particles Whatever the new 300-Gev accelerator brings, one can say without doubt that it will contribute greatly to our

knowledge in this fundamental field of modern physics.

Finally, if one compares elementary particle physics with astrophysics, one obtains a clear picture of what this science is and what its aims are At the present time, research into this world is moving in two main directions which, from the stand point of the problem, tend to diverge diametrically Man is querying and seeking the smallest and largest dimensions of the universe The boundary of the sub-nuclear world, the minute domain of the elementary particle, lies at one thousandth of one milliardth of a millimeter Research into the macrocosmos on the other hand extends 6000 million light years into outer space

The difference between these two disciplines of science can be charactensed in another way As a branch of nuclear physics is concerned with the structures of the fundamental building blocks, the nucleons, and astrophysics with events taking place in the cosmos, such as we are now experiencing with the discovery of the mysterious pulsars and quasars

Perhaps one day the two sciences will meet at a point at which the smallest reveals the meaning of the largest or vice versa.

NUCLEAR TRANSFORMATIONS IN NATURE -SOLAR PROCESSES

The problem of solar radiations remained one of the most puzzling riddles of science until the discovery of radio active transformations and the artificial transformations of elements revealed to us tremendous sources of energy hidden in the depths of atomic nuclei. We have seen that practically every element can become a nuclear fuel, liberating tremendous amounts of energy, provided it can be

heated up to millions of degrees Now, while such temperatures are practically unattainable on the face of the earth, they are rather common in the world of stars In our own sun the temperature increases gradually from 6000 C at the surface to twenty million degrees in the center

Two nuclear physicists, H Bethe and C Weizsacker, simultaneously found out that the nuclear process known as "carbon cycle" is responsible for the energy production in the sun This thermonuclear process is not limited to a single nuclear transformation, but consists of a sequence of transformations forming a reaction chain A most important feature of this process is that it is a closed circuit, returning to the starting point after every six steps The main participants of the process are the nuclei of carbon and of nitrogen, together with the protons with which they collide

Briefly the cycle is (1) A proton on colliding with an atom of normal carbon (C_{12}) liberates some subatomic energy in the form of gamma rays and transforms the atom to the lighter isotope of nitrogen (N_{13})

(2) The nucleus of N_{13} being unstable adjusts itself by emitting a positive electron or positive Beta particle and becoming the stable nucleus of the heavier isotope or carbon (C_{13}), which is known to be present in small quantities in ordinary coal

(3) This carbon isotope collides with another proton and is transformed into normal nitrogen (N_{14}) with additional release of energy in the form of gamma rays

(4) In the next step the nucleus of nitrogen collides with still another proton (third) and gives rise to an unstable oxygen isotope (O_{15})

(5) Which very rapidly transforms into stable N_{15} by emitting a positron

(6) Finally N_{15} receiving in its heart the fourth proton, splits into two unequal parts one of which is the C_{12} nucleus with which the process started and the other is a helium nucleus or alpha particle which is composed of two protons and two neutrons The same result would have been obtained if the process was started with normal nitrogen atom instead of carbon

The net result of the chain of reaction[15] is the formation of one nucleus of helium from the four protons which entered the process cycle successively accompanied with liberation of energy The nuclei of carbon and nitrogen in the closed circuit of reactions are forever being regenerated Thus the whole process may be described as the transformation of hydrogen (a proton is the nucleus of hydrogen atom) into helium due to very high temperatures assisted by the catalystic action of carbon and nitrogen

It is shown that at the temperature of 20 million degrees the energy liberation in the above circuit reaction coincides with the actual amount of energy radiated by our sun Since the astrophysical evidence renders all other possible nuclear reactions inconsistent it may be accepted that the carbon nitrogen cycle described above represents the process mainly responsible for the generation of the solar energy It should also be noted that at the interior temperature of the sun the complete circuit requires about five million years

15 Incidentally this particular reaction is quite well known to nuclear physicists and has been obtained under laboratory conditions by the use of artificially accelerated high energy protons

CHAPTER II

ATOM IN J A I N PHILOSOPHY

INTRODUCTORY

"Ever since men became capable of rational thinking, their actions have mostly depended upon their theories about the universe and its contents and also as to what is good and what is evil This is an almost eternal truth Men's environments play an important part to determine their way of living, but conversely their philosophy does much to determine their circumstances

"Philosophy is neither theology nor science but something of both It appeals to reason, rather than authority, like science, but like theology it speculates on matters about which definite knowledge is not ascertained Science is bounded by definite knowledge while dogma as to what surpasses definite knowledge belongs to theology Intermediate between them is philosophy

"Science will not, because it cannot, answer all the questions of great interest to human mind and if we forget what we cannot know, we become insensitive to many things of great value Are there two orders of existence? Is the universe a systematic unity or a conglomeration of multiplicity? Is reality objective or merely subjective? Answers to these and many other such questions cannot be found in the laboratories On the other hand, dogmatic belief that we have knowledge where, in fact, we have ignorance, induced by theologies and the very definiteness of the answers given by them causes modern mind to view them with suspicion It is the business of philosophy to study such problems and discuss them even if they

cannot be solved "[1]

Jain philosophy is one of the most ancient Indian philosophies According to the Jain canonical literature the same tenets are propounded again and again by various Tirthankaras by whom the truth is realised, and whose mission is to propagate right knowledge

Rsabha was the first of the 24 Tirthankaras References to him are found in Vedas in *Viṣṇu Purāna* and *Bhāgavata Purāna* 23 Tīrthankaras followed Ṛsabha Aristnemi the 22nd Tīrthankara was contemporary with Lord Krisna Pārsva the 23rd Tīrthankara is accepted by the modern historians to have lived in the 8th century B C After 250 years Pārsva was followed by Vardhmāna Mahāvira the 24th and last *Tīrthankara* Mahāvira lived for 72 years and attained *Nīrvāna* at Pāvāpurī in Bihār 2500 years ago The discussion of physical existence in general and of atom in particular has been very exhaustive in the Jain canonical literature Other Indian (and non-Indian) schools of philosophy have not treated this subject with such thoroughness

In the following pages, we shall briefly put forth the problem of atom as discussed in Jain canonical literature

I METAPHYSICAL VIEW

SUBSTANCE *(DRAVYA)* QUALITY *(GUNA)* CHANGE *(PARYAYA)*

NON-ABSOLUTIST REALISM

To grasp properly the Jain views regarding the problem of atom, it is necessary to understand the

1 Sir B Russell *History of Western Philosophy* pp 13 14

non-absolutist attitude of the Jains regarding the nature of existence We shall therefore very briefly review the non-absolutist realism of the Jain philosophy

Jains have developed perhaps a unique system of metaphysical thinking based upon their own unique epistemology which recognises both empirical and transcendental experience to be within the scope of human knowledge According to them firstly Reality is self-existing self-consistent and self-contained It does not depend upon something outside it for its *existence* Secondly the Jain system is free from all absolutism It does not deprecate commonsense interpretation of experience in favour of abstract *a priory* logic The logical attitude is intimately bound up with their empiricism

Jain definition of Reality is "what is capable of eternal continuous existence through infinite succession of creation and cessation"[2] And also "what possesses an infinite number of attributes"[3] A Substance is an ultimate reality and is therefore defined as "that which supports (i e possesses) both qualities and a succession of mutations"[4]

The development of the Jain philosophy is based on the doctrine of persistence-through-modes While the absolutist finds self-contradiction in asserting both permanence and change in the same reality with reference to identical space and time the non-absolutist Jains maintain that one need not be afraid of accepting this as a truth—as the very nature of things—since our common experience gives this as a fact

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2 *Utpada vyaya dhrauvyātmakam sat—Tattvartha* Sūtra 5 29

3 *Gunānamasao davvam—Uttradhyayana Sūtra* 28 6

4 *Guṇa prayāyasrvo dravyam—Jaina Siddhānta Dipikā*, 1-3

The Jain attitude is, thus, that of non-absolutist realism. It neither endorses absolute nihilism nor absolute eternalism, but explains both these extremes as real with reference to different aspects of the same reality. Jains do not believe in absolute permanence or total cessation. Both permanent and transitory attributes co-exist in a substance. Although experience never gives us mere persistence of an unchanging content, neither does it ever give us mere change without persistence. What we actually experience always exhibits the two aspects of identity and transition together.

All mutation *(paryāya)*, argue Jains, must be change *of* and *in* something, i.e. it is nought but succession within an identity, the identity being as essential to the process as succession. Where there is no underlying identity there is nothing to change. Thus, change is as much real as permanence, but by itself (apart from a background of identity) is, therefore, impossible.

The identity which pervades throughout the succession of changes could be a SUBSTANCE *(dravya)* or its QUALITY *(guna)*.[5] A thing e.g. a material mass possesses numerous attributes. It is at once white or green, hard or soft, rough or smooth etc. All these qualities belong to or inhere in it. What is this IT? It is called substance *(dravya)* i.e. a substratum of infinite qualities.

A substance does not exist without qualities because nothing can be (or exist) without being in some determinate way, and the qualities of a substance means its existance in a determinate way. One cannot divorce the existence of a thing from its

5 *Lakhaṇaṁ pajjavāṇaṁ tu ubhao assiyā bhave —Uttrādhyayana Sūtra*, 18-6

determinate mode of being Thus, the non-absolutist Jains assert that the qualities cannot be absolutely different from the substance nor can they be absolutely identical with it

SIX ULTIMATE REALITIES

Jains accept the existence of six ultimate realities as under (1) *Jeevāstikāya*, (2) *Dharmāstikāya*, (3) *Adharmāstikāya*, (4) *Ākāsāstikāya* (5) *Pudgalāstikāya* and (6) Time [6]

The first five are called astikāyas because each of them are homogeneous substances composed of innumerable points, Kāla i e , time is also included in the list of realities as the sixth entity, but is not an astikaya We shall examine very briefly the nature and characteristics of these substances before taking up the detailed discussion on *pudgalāstikāya* which is the Jain name for matter

(1) *Jeevāstikāya* is the psychic order of existence Consiousness is its chief characteristic It exists in two states (a) state of bondage and (b) state of emancipation In both these states its existence is real Emancipation does not mean total cessation nor is bondage merely empirical The emancipated soul is the same old self which was in bondage Freedom means freedom from passions

Emancipation presupposes corruption of the self in the state of worldly existence This corruption is due to soul's beginningless association with matter The soul is pure consciousness in its intrinsic nature and it is due only to its association with matter that it comes to generate passions

(2) *Dharmāstikāya* and (3) *Adharmāstikāya* are the media of motion and rest, respectively The

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6 *Bhagvati Sūtra* 13-4-481

existence of these two as ultimate substances is not accepted by any other metaphysical system. As science, however, accepts the existence of a substance called ether which assists the propagation of motion, we shall, for the sake of convenience translate these terms as positive and negative ether respectively.

Each is a single, indivisible, homogeneous entity, pervading the entire inhabited universe (*loka*), but not beyond it. In fact, they are the cause of the finiteness of the *loka*. Temporally they are eternal. They are devoid of smell, taste, etc. and therefore imperceivable by the sense organs. Immobile themselves, they assist the motion of mobile objects, positive ether is the medium of dynamic state and the negative ether is for the static state. Not even the minutest vibration is possible without these media. Hence where there is no ether there is neither psychic nor material existence.

(4) *Akāsāstikāya*—space. According to Jains, space is an objective reality. It is the container of all other substances. It is boundless—infinite. Ethers and other substances do not inhabit the whole space as they are finite. That portion of space which is inhabited by other substances is called loka or active universe.[7] *Loka* is finite and is surrounded in all directions by *Aloka* or inert, empty space—a boundless void.[8] Actually, the space is one indivisible entity. The ethers determine the boundaries of the *Lokākāshā* by their own finiteness.

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7. *Kimiyaṁ bhante ! Loyeti pavvuchchai ? Panchāthikāyā easa naṁ evatiye loyeti pavvachchai, taṁjahā-dhammathikāye jāva puggalāthikāye* –*Bhagvati Sūtra*, 13-4-13

8. *Svalakṣanam hi lokasya ṣaddrvyasamvāyātmaktvaṁ, alokasya kevalaṁ, akāśātmakatvam.* *Pravachanasara* 2-36 *Pradipikāvṛtti*

(5) *Pudgalāstikāya*-Matter What is commonly known as matter is called pudgala by Jains The use of this word is almost exclusive to the Jain literature It is a derivative made up of two words[9] 'put' which means joining or fusion and 'gala' which means dissociation or fission which characterizes only one substance that is matter The properties of fusion and fission have given the name 'pudgala' to this substance

It should be noted that though *Dharma*, *Adharma*, and *Ākāsha* do not possess consciousness, they are definitely not material The characteristic quality of matter is that it possesses the properties which can be perceived by sense organs[10] viz colour, smell, taste and touch Concomittance of all the four is emphasised by the Jains In other words if a thing is perceived by the sense of touch, it must also necessarily posses smell taste and colour The structure of matter is as its name implies different from the other substances Whereas the other four *astikāyas* are indivisible matter is divisible The ultimate indivisible unit of matter is called *PARAMĀNU*

It should also be noted that Jains do not differentiate basically between matter and energy And so, the word pudgalastikaya covers both—matter and energy

(6) *Kāla*—Time

Time is not an *astikāya* but it is a reality That is why it is not included in the list of *astikāyas* but is included in the list of six *dravyas* Time is the necessary condition of duration (continuity) change (modification), motion, newness and oldness of sub-

9 *Pūranagalanānvarthasamjnatvat pudgalāh —Tattvārtha Rājavārtikam*, p 190

10 *Sparsa-rasa-gandha-varnavantaḥ pudgalāh—Tattvārtha Sūtra*, 5-23

stances[11] Though time by itself cannot cause a substance to exist, continuity of existence implies duration in terms of time Mutation or change of modes also cannot be conceived without time because change naturally implies temporal succession in which the modification takes place Similarly, motion implies different positions in space of an object in temporal succession Lastly, time causes the distinction between the old and the new the before and the after The ultimate indivisible unit of time i e time-point is called *Samaya*

After this brief description of the six ultimate realities we are now ready to take up discussion on *pudgalāstikāya*

II

PUDGALA DEFINITION & CLASSIFICATION

MEANING OF THE WORD *'Pudgala'*—

Matter is called pudgala by Jains The usage of this word *pudgala'* is not found in any other philosophy except Buddhist, where also it is in quite a different sense viz consciousness It has the following derivation[12]

'Pud' means to combine and *'gala'* means to separate Hence the basic meaning of the word *Pudgala* is 'That which undergoes modifications by combination and separation' In the words of the modern science we can say 'that which is fissonable and fusionable is *'pudgala'*

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11 *Kālaḥ Samayādiḥ*
Vartanā pariṇāma kriyā paratvāparatvādibhir lakṣyaḥ
-*Jaina Siddhānta Dipikā*, 1 22-23

12 *Sabda Kalpadruma Koṣa*

DEFINITIONS

Jain canonical literature defines *pudgalāstikāya* as 'perceivable by senses by virtue of possessing sensible qualities viz , five colours, five tastes, two odours and eight touches, it has form & extension, it is devoid of consciousness and life, it is eternal in its nature, constant in quantity (i e neither increasing nor decreasing) and is a fundamental constituent of the universe ' It pervades the whole of *lokākāsha*[13]

Out of the five *astikāyas* which constitute the universe, pudgala is the only one which possesses form and is perceivable by the senses [14]

From different aspects the matter is also defined as under -[15]

1 Substantially matter *(pudgala)* is infinite in number

2 Spatially matter fills the whole active universe *(loka)*

3 Temporally matter is eternal i e without beginning and without end

4 Qualitatively matter possesses colour taste odour and touch

5 Interactionwise matter is capable of being absorbed and assimilated by *Jeeva* (psychic order of existence).

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13 *Bhagwati Sūtra,* 2-10

14 *Brhad Dravya Saṁgraha,* Verse 15

15 *Se samāsao paṁchavihe paṇnatte*
Davvāo ṇaṁ poggalāthikāye aṇaṁtāviṁ davvāviṁ
Khettao loyappāmaṇamette
Kālao ṇa kayāi ṇa āsi jāva ṇichche
Gunao gahaṇa guṇe —*Bhagvati Sutra,* 2-10

CLASSIFICATION (OF MATTER)

Different types of material composite bodies constituting the physical order of existence can be classified from various aspects Substantially matter is infinite[16] i e there are infinite number of composite bodies as well as infinite elementary particles and is conversely, therefore fissionable into infinite components Spatially it is infinite because each space point of *loka* is occupied by infinite bodies and *paramānus* Temporally it is infinite because it is indestructible And because infinite qualities inhere in matter it is qualitatively infinite also[17] Thus there could be infinite types of matter[18] And since each of these infinite types are capable of infinite mutations and transformations the entire physical existence is infinitely infinite[19]

A UNIQUE SUBSTANCE

Non-absolutist Jains therefore accept the infinite diversity of physical existence and do not find any contradiction in the fundamental (basic) unity and the infinite multiplicity of the material world On the contrary, according to their non-absolutist attitude, the reality of infinite multiplicity emphasises the substantial unity of matter Since the whole material universe is composed of the ultimate elementary particles viz *paramānus*, substance-wise it is a unity All matter in its ultimate analysis is nothing

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16 *Davvao ṇaṃ poggalathikāye anantāvmṃ davyaṃṃ—Bhagavati sūtra* 2-10-57

17 *Davva desena savve poggalā sapayesā vi appayesa vi anantā khettā deseṇa vi evam cheva, kāla deseṇa vi bhāva deseṇa vi evam cheva—Bhagavati Sūtra*, 5-282

18 *Anantāta bhedā api pudgalāḥ—Tattvārtha Rājvartikaṃ* 5-25-3

19 *Bhagavati Sūtra*, 25-4-41 and 25-4-66

but the elementary particle and the elementary particle in its free state is matter itself From this aspect there is only one class or type viz *paramāṇu*

B TWO CATEGORIES

Elementary particles combine together and produce composite bodies of matter Thus a body produced by the association of elementary particles is a material aggregate called *skandha*' From this point of view the matter is classified into two types 1) *paramāṇu* or free elementary particle and 2) *skandha* i e composite bodies made up of these particles Composite bodies are again of two types 1) *chatuḥsparśi* and 2) *aṣṭasparśi* *Chatuḥsparśi* bodies as their name indicate have only four *sparśa* viz hot or cold, dry or unctuous *Aṣṭasparśi* bodies on the other hand have heaviness or lightness and hardness or softness (or roughness or smoothness) This means that *chatuḥsparśi* bodies are *agurulaghu* i e neither heavy nor light In other words they are massless The quality of mass is acquired when the material bodies become *aṣṭasparśi skandhas*

From some other aspects also matter can be classified into two types

One of them is capability of sensuous cognition which gives two types (i) *sukṣma and ii) bādara* The type of matter which cannot be perceived by normal sensory equipment is *sukṣma* or minute Since sense organs are incapable of cognising *paramāṇus*, all *paramāṇus* fall in this class viz *sukṣma* Structure of some material bodies render them

20 *Samasta—Pudgalā eva dvividhāḥ—*
paramāṇavah skandhaśceti

-Tattvārtha Sūtra with
Siddhasena s Commentary 5-25

incognisable by the sense organs and these also fall in this category, while those aggregates which are perceivable by the sense organs are called *bādara* or gross

Only some *aṣṭasparsī* aggregates are perceivable and are therefore *bādara* Again, all aggregates composed of two five, ten upto innumerable *(asamkhya)* particles are *sukṣma* Even those aggregates which are composed of infinite particles but are *chatuḥsparsī* are *sukṣma* Aggregates composed of infinite particles and which are *aṣṭasparsī* are *bādara* as well as *sukṣma*

Matter can also be classified into two types from yet another aspect viz., capability of being associated with *jeeva* i e conscious substance We have stated that matter is attracted by and becomes associated with *jeeva* Thus we have two types of matter (1) associable and (2) non-associable with *jeeva* All *paramāṇus*, in their free state cannot be attracted and therefore fall in the first category Amongst the composite bodies some are associable while some are not

C THREE TYPES OF MATTER

Matter can be classified into three types from the aspect of the cause of transformation viz., i) *prayoga pariṇata* ii) *miśra pariṇata* and iii) *visrasā pariṇata* [21]

i) The matter which is associated with conscious substance *Jeeva* is *prayoga pariṇata* i e being transformed by the vital processes Bodies of the living organisms are instances of this class

ii) The matter which was associated with *jeeva* in the past but is not now in contact with it and

21 *Tivihā poggalā paṇṇattā-paoga pariṇayā, misasā pariṇayā, visasā pariṇayā* —*Bhagavati Sūtra*, 8-1-1

therefore is no longer transformed by the agency of vital processes but undergoes auto-transformation is *misra* (mixed) *parinata* Shoe-leather is an instance of this class Transformation which is partly under the influence of *jeeva* and partly auto-transformation, is also *misra parinata*

iii) Matter which is self-transforming i e which has no interaction with *jeeva* is *visrasā pariṇata* Radio active elements are instances of this class

D FOUR TYPES OF MATTER[22]

From constitutional aspect, matter can be classified into four types, viz ,

i) *Skandha*

(ii) *Skandha-desa*

(iii) *Skandha-pradeśa*

(iv) *Paramānu*

(i) *Skandha* *Skandha* is defined as an individual aggregate composition formed by an association of elementary particles or smaller composites The smallest *skandha* is a *'dvipradesiya' sakndha* produced by the combination of only two *paramānus* and the largest is *'achitta mahāskandha'* which is the material body extending over the whole *loka*

ii) *Skandha-desa,* A part of the whole is *'desa'* Thus a portion of any individual composite is *skandha-desa* Since an aggregate is divisible it can be considered as made up of a number of portions It should be remembered that division is merely conceptual When, on the other hand, a composite aggregate breaks up into fragments, each fragment

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22 *Je rūvi te chauvvihā paṇṇattā — Khandhā Khandhadesā, Khandhapadesā Paramāṇu poggalā* — *Bhagavati Sūtra* 2-10-66

becomes an aggregate i e *skandha* and not *skandha-deśa*

iii) *Skandha-pradesa* *Pradesa* means a point, i e indivisible part Therefore the smallest indivisible portion of an aggregate is *Skandha-pradeśa* Again the division is merely conceptual i e the portion is not a detached free portion but an imaginary one in the aggregate

iv) Paramāṇu The word is derived from '*Parama*' and 'Aṇu' Parama means the ultimate and *Anu* means small (particle) According to Jain micro-cosmology, *paramānu* is the ultimate elementary particle, the origin of the whole material existence Thus the infinitesimally small, indivisible and free i e unattached to another particle of matter is *paramāṇu* *Paramānus* are the ultimate building blocks which by mutual combination produce the whole of material universe So long as it is considered to be a portion of an aggregate it is *p adeśa* while in its free i e unattached state it is *paramānu*

E SIX TYPES OF MATTER

From the point of view of size matter is divided into six classes [23]

i) *Sthūla-sthūla* (or *bādara-bādara)* means very gross

ii) *Sthūla* (or *bādara)* means gross

iii) *Sthūla-suksma* or *(bādara-suksma)* means gross fine

iv) *Sukṣma-sthūla* means fine gross

v) *Sukṣma* means fine

vi) *Suksma-suksma* means very fine

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23 *Gommatsāra Jeevakānda gathā* 602

In *Niyamsāra*;[24] Kundkunda has illustrated these six classes thus

i) Very gross are very large solid aggregates of matter such as mountains) which may be broken and divided and also such bodies which can be physically transported (without a container)

ii) Gross are large aggregates of matter which cannot be broken and which have to be carried in containers i e liquids

iii) Aggregates which can neither be cut nor broken nor can be physically transported but are visible e g light shadow, image etc , are gross fine

iv) Fine gross are those aggregates which are not visible but can be perceived by other four senses —ultra visible but infra sensual e g gases

v) *Sūkṣma* or fine aggregates are ultra sensual i e those which are imperceivable to any sense organs These are bodies of matter which function as the media of thought and speech i e *manah varganā* and *bhāṣā varganā*

vi) *Sūkṣma-sūkṣma* or very fine are those bodies which are even finer than those used in the process of thinking These are *Kārmaṇa* groups of matter, bodies made up of less than infinite number of particles and *paramāṇus*

F TWENTY-THREE TYPES OF MATTER

Beginning from *paramāṇu varganā* and ending with the *achitta mahāskhandha varganā*, there are infinite number of groups of matter But it is possible to reduce the number of *varganās* to twenty-three by

24 *Niyamsārā*, 22 24

grouping them from certain aspects[25] First of all there are free unattached solitary *paramāṇus* which form '*paramānu varganā* The second group contains composite of two *paramāṇus* The third group contains composites of three *paramānus* and so on We then come to a group which contains bodies of innumerable *(asamkhyāt)* number of *paramāṇus* All these *vargaṇās* are not capable of being associated with *jeeva* We are mainly concerned with the following eight important *varganās* which interact with the psychic order of existence and these we shall therefore discuss in some detail

i) *Audārika Varganā* All material compositions large and small which are or can be made perceivable by sense organs belong to this group All organic material which make the cells (blood, bone skin etc) comprising the bodies of all living and dead organisms (including the entire vegetable kingdom) and inorganic atoms molecules and compounds in short almost all things encountered by us in everyday life belong to *Audārika Varganā*

ii) *Vaikriya Varganā* Celestial bodies of the inhabitants of heaven *devas* and hell *(nārkis)* are composed of the material of this group which is very much more subtle than the previous group

iii) *Ahāraka Varganā* The material of this group is very much finer than the preceding ones It is used by ascetics who have acquired special powers, to produce an astral body (called *āhāraka sarīra*) The learned sage uses this type of body for visiting omniscient persons at far off places, for the purpose of clarifying some doubts

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25 *Gommaṭasāra, Jeevakāṇḍa gātha* 593 594

iv) *Taijas Varganā* (Luminous body) The material belonging to this group is used by the soul to make a subtle body which always accompanies the soul in its mundane existence i e until it achieves emancipation The body forms an essential link between the soul and its *kārmana sarīra* Energy required by the vital processes of the living organism is provided by the *taijas* body

v) *Swāsochchhvās* or *Anāpāna Varganā Svāsochchhvās* means respiration, as indicated by its name, matter in this group is what all living organisms need and use for breathing

vi) *Bhāsā Varganā* Bhāṣā means speech Living organisms which are capable of producing speech [26] give voice to their feelings The matter of this group is essential for this process

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26 Jains divide the entire living universe (the psychic order of existence) into five classes on the basis of the number of sense organs possessed by them thus

1) In the lowest class are beings possessing only one sense organ viz that of touch i e tactile They are therefore called *Ekendriya* These are again of five types

(i) *Prithvikayika* i e earth beings

(ii) *Apakāyika* i e water beings

(iii) *Tejaskāyika* i e fire beings

(iv) *Vayukāyika* i e air or wind beings

(v) *Vanaspatikāyika* i e vegetable kingdom

These five are also known as *Sthāvaras* or immobile

2) *Dwindriya* class is constituted by the creatures possessing two sense organs i e those of touch and taste i e tactile and gustatory

3) Creatures of *trindriya* class possess three sense organs viz those of touch taste and smell i e tactile, gustatory and olfactory

4) *Chaturindriya* class is constituted by those who possess the

vii) *Manah or Mānas Varganā* *Mana* means mind According to Jains, mind is an instrument of thinking which a soul makes for itself out of material bodies and becomes capable of thinking through its agency The material in this group is fit for this purpose

viii) *Kārmana* or *Karma Varganā* Matter of this group also called Karmic matter is responsible for corrupting the soul and keeping it in bondage Minutest activity of a living being—physical, mental or oral—attracts the Karmic matter which unites with the soul and is then assimilated and transformed into *Kārmana śarira* which is the basis of the mundane (in bondage) existence of the soul

It is to be noted that a composite body of the group successively consistes of greater number of *paramanus* which are more compactly packed and thus occupies less space Thus a body of *Ahāraka varganā* is more compact and occupies less space than a body of *Vaikriya Varganā* which itself is more densely packed in comparison with a body of *Audārika vargana.*

G INFINITE CATEGORIES

Colour, taste, smell and touch are the innate qualities of matter There are five primary colours five tastes, two smells and eight touches A *paramā-*

sense organs of sight (vision) besides the three cited above

5) In the highest bracket are those who possess all five sense organs i e they are capable of hearing in addition to possessing the four sense organs named above According to Jain scriptures, besides human beings and sub-human animals *devas*—inhabitants of heaven and *nārkis*—denizens of hell constitute this class All except the *ekendriya* group are capable of taking in *Bhāsā* material and transforming it into speech

nu has one primary colour, one taste, one smell and two touches viz., hot or cold and dry or unctuous. It is easy to see that on the basis of the quality of touch there would be four varieties of *paramānus* and with permutation and combinations of other qualities we will have 200 varieties. Then again the strength or intensity of each quality varies from one unit to infinite units. Thus there would be infinite varieties of *paramānus*. Similarly depending upon the number of *paramānus* of different varieties participating in making a composite, we will have infinite varieties of composite bodies. Material universe comprised of solids, liquids, and gases atoms and molecules, light and darkness, sounds and shadows, is therefore, infinitely infinite.

III
PROPERTIES OF MATTER

i) Matter is a substance. it is eternal and *avasthita* i.e. non-transmutable (into another substance)[27]

ii) Matter is real composite and devoid of consciousness.[28]

iii) Matter possesses sensible qualities viz. colour taste smell and touch and is therefore an object of sensual cognition.[29]

iv) Matter is (capable of being) active.[30]

v) Matter is fusionable and fissionable.[31]

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27 *Nityāvasthitānyarupāni cha—Tattvārtha Sūtra*, 5 3

28 *Ajīvakāyā dharmādharmākāśa pudgalāḥ-Ibid*, 5 1

29 a) *Rūpiṇāḥ pudgalāḥa-Ibid* 5 4

b) *Puggala mutto rūvādiguṇo—Brhad Druvya Saṃgrha*, verse 15

30 *Pudgalā Jivāstu Kriyāvantaḥ—Tattavārtha Sūtra* 5 6 (Bhasya)

31 *Pooranād galanāchcha pudgalaḥ-Ibid*, 5 1 (commentary)

vi) Matter is *Parinami* i e mutable [32]
vii) Material atoms and bodies are infinite in number [33] and they fill the entire *loka* i e active universe [34]
viii) Matter interacts and influences the psychic order of existence i e *jeeva* [35,36]

We shall now discuss the above characteristics of matter in detail

i) a MATTER IS A SUBSTANCE

We have already discussed the general characteristics of a substance in the beginning of this chapter Qualities and modes inhere in a substance [37] Properties and attributes are qualities, characteristics are also qualities A substance is never devoid of qualities and is cognisable through them Distinction between different substances can be made by the possession or non-possession of special qualities

Paryaya [38] Mutation is the succession of modes within the identity of either the substance or the quality While a quality inheres permanently, modes are always transitory In other words while the substance and its qualities are indestructible and

32 *Parinama parinaminau jivapudgalau svabhāvavibhāva - pary ayabhyam kriya* *Brihad Dravya Samgraha* page 67

33 *Davvao ham poggalathikāye ananataim davvāim—Bhavagati Sūtra* 2 10

34 *Khettao loeppamānamette–Ibid ibid*

35 *Sakaṣāyatvājjīvāḥ karmano yogyān pudgalānādatte Tattvārtha Sutra* 8 2

36 *Sarirāvānmanah prānāpanāh pudgalānām sukhaduhkhajivit amaranopagrahāscha-Ibid* 5 19

37 *Gunaparyayavad dravyam —Ibid* 5 37

38 *Bhāvāntaram samjñāntaram cha parvāyaḥ-Tattvārtha Sūtra (Bhasya)* 5 37

inseparable,[39] their permanence is through incessant modification A mode has a beginning and an end The end of the old mode would necessarily be the commencement of a new one and the change is as much real as the permanence [40]

Just as a quality is neither absolutely different from nor absolutely identical to the substance in the same way modes are not absolutely different from qualities In fact they are nought but succession within the identity of a quality and this attribute of succession within an identity is known as mutation Take for instance, a golden bangle and a golden ring In both the specific qualities of the element gold inheres uniformly but the mutability of the gold to be transformed into different shapes and sizes makes it possible to become sometime a bangle and sometime a ring This transformation of shapes is mutability and the shape for the time being is a mode The bangle-mode can be destroyed to create the ring-mode but the goldhood is permanent or identical in both Thus matter is a substance which is never destroyed i e never becomes a non-material identity[41]

b MATTER IS INDESTRUCTIBLE AND *AVASTHITA* (NON-TRANSMUTABLE)

Permanence and conservation are universal qualities of all substances Permanence is defined as

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39 *Anantastrikāla-viṣyatvād aparimitāḥ ve dharmaḥ sahabhāvinaḥ kramabhāvinascha paryāyāḥ-Syādvādamañjari* Commentary of Sloka-22

40 *Utpāda-vyaya-dhrauvya-yuktam sat -Tattvārtha Sūtra* 5-29

41 *Aparityakta svabhāvenot pāda-vyaya-dhruvtva saṁyuktaṃ Guṇavachcha saparyāyaṁ yattaddrvyamiti bruvaṁti Pravachanasara,* 2-3

'immunity from being destroyed as substance' Conservation is the quality which enables the matter to continue and maintain its material existence inspite of its intimate association and interaction with other substances

Thus although certain types of material bodies are attracted, transformed and assimilated by the conscious substance, at no time do they lose their material identity but remain eternally material On the other hand its most intimate interaction with conscious substance can never transform the latter into matter[42]

In the infinite past the matter existed as matter in the present it exists as matter and for the infinite future it will continue to exist as matter Matter persists through modes but is always eternally matter. It can never absolutely be destroyed nor be absolutely transmuted i e become non-matter[43]

The total quantity of matter in the universe is always constant whatever was the quantity in the infinite past will always remain the same in the infinite future Not a single *paramānu* (ultimate particle) has been totally destroyed in the past nor will it be destroyed in future Not a single *parāmaṇu* was newly created in the past nor will be created in future[44]

ii) a MATTER IS PHYSICAL, NOT PSYCHICAL ORDER OF EXISTENCE

What is devoid of consciousness is *ajeeva* Matter is

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42 *Jīvo na bhavatityajeevah*

43 *Tadbhāyāvavyayam nityam–Tattavārtha Sūtra* 5 30

44 *Avasthita grahaṇādanyūnādhikatvamāvirbhāvyate anādinidh aneyatābhyām na svatattvam vyabhicharanti–ibid, Siddhsena s Commentary,* 5 3

eternally unconscious, it is not capable of knowing and is bereft of feeling is not psychical It belongs to the physical order It is *ajeeva* [45]

b MATTER IS AN (ULTIMATE) OBJECTIVE REALITY

Matter is real It is not imaginary Real existence is the basic inherent quality of all the five *astikāyas* [46] including matter *(pudgalāstikāya)*

Existence is inherent in matter and not external or induced [47] It possesses qualities and modes and it persists through modification [48] Matter exists objectively and is not merely subjective or a figment of mind It is not '*aupchārika*' i e postulated It does exist and is eternal [49]

c MATTER IS COMPOSED OF ELEMENTARY PARTICLES

When it is said that matter is an *astikāya* it is meant that it is a composition of constituents [50] *Kāya* means body and like a body whatever is made up of a multiplicity of constituents is called 'kaya' [51] Aggregates (molecules) of matter is composed of two to

45 *Jeevādanyoajeeva sata eva vastuno abhimatah Vidhipradhānatvat atastutvāstitveva bhāvesu chaitnya nishedhd dvārena dharmādisvajeevā ityanushāsanam*

46 *Iha vividha lakshnānam lakshanamekam saditi sarvagatam-Pravachansāra* 2-5 (chhaya)

47 *Astitvam hi kila dravyasaya svabhāvaḥ-Pravachansāra* (Commentary) 2 4

48 *Sadhbhāvo hi svabhāvo gunaiḥ saha pravayai schitraiḥ dravyasya sarvakālamutpādvayadhruvatvaih-ibid* (chhaya) 2 4

49 *Asti ityayam nipātaḥ kāltavābhidhāyee-Bhagvati Sūtra (commentary)* 2 10

50 *Kāyaḥ pradeshharāshyaḥ-ibid* 2 10 (commentary)

51 *Kāyā iva bahu desā tamhā yā kāva athikāya va Brihad Dravaya Samgraha* 24

infinite constituents The ultimate elementary particle—*paramāṇu* is of course a unit But since many unit particles assemble and constitute an aggregate, *paramānu* is also a potential body i e it can be virtually regarded as *kāya*[52]

iii) MATTER IS SENSUOUS AND IS PERCEIVABLE

It is sensible and so is cognisable by the sense-organs Colour, taste, odour and touch are the characteristic qualities of the physical existence[53] These sense-data affect the sense organs and are cognised by them, and hence matter is perceivable by sense organs

Matter is the only substance in the universe which possesses sensible qualities, others do not Only what is inherently sensuous is capable of being perceptible under certain conditions Infinite modifications of colour, taste odour and touch renders it to become perceivable[54]

Whatever is sensuous must necessarily belong to the physical order[55] Nothing which is of the physical order could be bereft of the qualities of colour etc ,[56] because they are not absolutely different from the material existence—whatever is bereft of sensuous

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52 *Lvapadeso vi anu nānākhandhappadesdo hodi bahudeso uvavara ti na ya kāyo bhananti savvachu—ibid* 26

53 *Sprshah resah gandhah varna itvevamlakhsanāh pudgalāḥ bhavanti— Tattvartha sutra* 5 23 (commentary)

54 *Rooparasagandhasparshā eva vishista pariṇāmānugrihitaḥ santo mūrtivvyadeshbhājo bhavanti Siddhasena commentary of Tattvartha Sutra* 5 3

55 *Pudgalā eva rupiṇo bhavanti—Tattvārtha Sūtra* 5 4 commentary *(Bhāṣya)*

56 *Na moortivyatirikeṇa pudgalāh santi Tattvārtha Sutra Siddhsena's Commentary*, 5 4

cognition is not material[57] *Roopatva*— sensible perceptibility—is the sum total of the four sensuous qualities named above Colour and/or extension by itself is not the cause of perceptibility of the matter All the four qualities are concommitant[58] No modification of matter is such that it possesses three, two or one of the four qualities Nor is there a modification of a substance other than matter which can possess one, two or three or all the four above qualities

All mutation of matter be it a single ultimate elementary particle or an aggregate constituted by innumerable such particles must possess all the four qualities

Samsthāna is an additional characteristic besides the above four which characterises sensuousness of matter It means form or shape It may be regarded consequential to fissionability and fusionability of matter

Five types of primary colour are	Black blue red, yellow & white
Five types of taste	Sweet bitter pungent acidic (sour) astringent
Two types of odour	Good smell and bad smell
Eight types of touch	Hot cold unctuous dry hard Soft (or smooth rough) light heavy

Two types of forms are

1) Symmetrical and

2) Assymmetrical

3) Some of the symmetrical forms are spherical, circular triangular, square, etc

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57 *Aroopāḥ pudgalā na bhavanti-Ibid* 5 4

58 *Yatra roopa parināmah tatrāvshavantayā sparsha – rasa gandhairapi bhāvyam atah sahacharametachchatustayam Ibid* 5 3

IV) MATTER IS KRIYAVAN i.e. (CAPABLE OF BEING ACTIVE)[59]

a. Non-absolutist Jains do not believe in absolute permanence or total cessation. They neither endorse absolute nihilism nor absolute eternalism but explain both these extremes as real with reference to different aspect of the same reality. According to them both transitory and permanent attributes co-exist in a substance. This is the fundamental or basic nature of the entire real existence. The permanence of the substances is attributable to their underlying indentity of qualities, while incessant series of successive states which make up the carrier of a thing are the expression of its mutable structure. Thus a substance can be considered eternal and therefore immutable if one examines it from the view point of *dravya* i.e. its underlying unity and ignoring (but not denying) the other aspect.

On the other hand it must be considered as incessantly changing if looked at from the view point of *paryāya*[60] i.e. its transitional attribute which establishes its mutability. And since all substances possess both attributes simultaneously they are both immutable as well as changing. In short they are subject to the doctrine of permanence-through-modification.

b. Mutation is thus an innate capacity of being active and since the mutation is infinite, *kriyā* is also infinite.

All modification can however be grouped under two types.

i) *Artha-paryāya*. It is incessant continuous

59 *Pudgalā jeevāstu kriyāvantaḥ- Tattvārtha Sūtra* Bhasya, 5.6

60) *Dravyārthika gaunabhâve paryāvārthika prādhānvat sarvabhāva utpādavyaya-darsānāt sakriyā anityaschetı Rajavārti kam* 5-7-25

(without break) and instantaneous and a universal attribute of all substances It is the change of state due to its own basic transitory element existing in all substances [61]

ii) *Vyañjana-paryāya* on the other hand is two-fold (a) *svabhāva* i e due to its own basic nature and (b) *vibhāva* i e interactionary Only two—*jeeva* and *pudgala*—out of the six ultimate substances undergo this type of modification The interaction mentioned above is between the consciousness-in-bondage and the matter It is neither incessant nor continuous

c Another type of activity is the capability of becoming dynamic Some substances are capable of different kinds of motion while some are incapable *Dharma* *Adharma* and *Ākāsha* are completely devoid of vibrations of any kind The pure i e uncorrupted psychic substance is also motionless Mundane soul however has the power to vibrate and by its interaction with material substance during the mental, vocal and bodily activities vibratory motions occur in the psychic substance Matter is capable of both dynamic and static states It is capable of motion with and without movement and other dynamic activities Its dynamic state is *kriyā* and static state is *parināma* [62]

d In the annotation of *Tattvartha Sūtra* (5 – 6) it has been stated that matter and *jeeva* are active *(kriya-vān)* substances[63] whereas the other substances are inert *(Nişkriya)* This is in respect to their incapacity

61 *Pratisamaya-parinatisvroopā arthaparyāyā bhanyante Pari nāmāt ek samayavartino arthaparyāyāḥa Pravachanasāra (tātpa ryavritti)* 2 37

62 *Parispandātmakaḥ kriyetvākhyatā, itaraḥ parinamaḥ* -

63 *Pudgala jeevāstu kriyavantah*

of assuming dynamic states[64] Now *jeeva* is dynamic only in its worldly existence which itself is due to its association with karmic matter[65] Ultimately when *jeeva* achieves emancipation and freedom, its association with physical order of existence is completely destroyed In its pure state *jeeva* is at complete rest in space and does not vibrate Conversely as long as *jeeva* is spatially dynamic it will continue to attract *kārmic* matter and cannot achieve emancipation

e Vibration is one type of dynamic activity[66]

Vibratory activity is an inherent quality of matter and that is why matter is dynamic in space In other words matter is capable of releasing energy because of its own capacity to vibrate[67] Consequently matter is dynamic in its own right[68] It is not absolutely immobile static or inert At the same time it should not be construed that all matter is active everywhere at all times and underall conditions It is sometimes active and sometimes inert (at rest)[69] A *paramānu* (free ultimate particle) can remain at rest on a single space point for sometime In short, the dynamic activity of matter is not continuous and there are periods of rest[70]

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64 *Pudgala jeevavartinee yā viseṣa kriyā desāntara prāptilakṣaṇā tasyāh pratiṣedhoyam-Tattvartha Sūtra, Siddhsena's Commentary* 5 6

65 *Kārmaṇa śarirālambanātmapradesaparispandana roopā kriy ī—Tattvārthasutra slokavārtika.* 2 25

66 *Parispandana lakṣaṇā kriyā Pravachanasar* 2-37 *Pradipika vriti*

67 *Pravachanasar* 2 37 *Pradipika vriti* 5 7

68 *Sāmarthyat sakriyau jeeva pudgalenīti nischayah Tatt Slokavārtikam,* 5 7 2

69 *Paramāṇu poggalesiya eyati, veyati, jāva pariṇati, siya no eyati jāva no pariṇati-Bhagavati Sūtra,* 5 7 150

70 *Egpayesogadhe poggale seye tammui vā thāṇe, annammi vā*

There are many types of *kriyā* (activity) and primarily each *kriyā* is different from the other But different types of energy manifestations can be grouped together on different basis On the basis of causality there are two types of *kriyā*

i) Spontaneous release of energy caused by its own innate capacity and

ii) Activation caused by external forces

In another way *kriyā* is of two types i) motion and ii) fusion-fission

Again the motion may be vibratory or migratory

Vibrations are again of two types i) simple and ii) complex

Two types of migratory motions are i) without changing direction i e in a straight line and ii) with change of direction In the *Bhagavatī Sūtra*[71] a few instances of different kinds of motions are given thus Motion may be spontaneous or caused by outside forces It is not eternal i e matter is sometime in motion and sometimes at rest It sometimes vibrates it sometimes vibrates and also rotates and so on upto the time when it changes its mode By the word 'so on' here we understand that besides simple and complex vibrations there are many other motions but what these are is a matter of research Commentator Abhayadeva Sūrī also has in his commentary suggested investigation in this field

In the Bhagvatī *sūtra*[72] motion without movement is called *'eyati'* which means *kampana'* or vibration Some types of migratory motions are (a) *anuśrenī* vs *viśreni*, *avigraha* vs *vigraha* and *riju* vs *kutila* (b)

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thāṇe jhaṇṇeṇam egam samayam ukkoseṇam ānaliyāe asamkhejjai bhāgam chiram hoi—Ibid 5 7

71 *Bhagavati Sūtra*, 2-3

72 *Ibid* 5-7-150

Pratighāti vs *apratighāti* (c) *Sṛpriṣṭa* vs *aspriṣṭa* and (d) *Urdhva-adhah-tiryaga.*

Some types of dynamic activities enumerated in *Bhagavati Sūtra* are -

1) *Sivā eyayi* (simple vibration)
2) *eyavi* —(complex vibration)
3) *Chalayi* (motion)
4) *Fundayi (spandana)*
5) *Ghattayi (samghatana)*
6) *Kouvvayi* (forceful penetration) and
7) *Udirayi* (transformation)

V) MATTER IS FISSIONABLE AND FUSIONABLE

a) The very name *pudgala* is derived by the virtue of the matter possessing the qualities of being fusionable and fissionable [73] *Put (puran)* means fusion and *gal (galana)* means fission In other words the processes of fusion and fission are inherent properties of the material universe

The ultimate elementary unit of matter is *paramānu* [74] These elementary units unite together to form material composites The union of *paramānus* follow certain rules and is subject to certain conditions Aggregates break up into smaller aggregates and/or *paramānus* The number of *paramānus* participating in a fusion process may vary from two to infinite The unity formed by fusion of multiplicity of *paramānus* is called *skandha* i e an aggregate or composite body [75]

Two or more aggregates may also unite to form one larger body Similarly the fission of an aggregate

73 *Pudgala sabdasyārtho nirdiṣtah pumgilanāt puraṇagalanādvā pudgala iti—Tattvārtha Rajvartikam*

74 *Kāraṇa-meva tadantyamsūkṣmo nityascha bhavati paramāṇuḥ-Tattvartha Sūtra, (Commentary)* 5 25

75 *Pariprāpta bandha parināmāh skandhāḥ-Tattvārtha Rājvārtikam,* 5-25-16

may give i) *paramāṇus* or ii) smaller aggregates or iii) *paramāṇus* and also aggregates Sometimes, one or more *paramāṇus* only may separate leaving the main aggregate intact Similarly one or more *paramānus* may unite with an aggregate

b) The process of fusion is called bandha i e association The process of fission is called *bheda* i e disassociation The word process (*prakriyā*) is used here to distinguish it from the (*kriyā*) dynamic activity of motion The infinite variety of the material universe and colossal energy of matter is due to its being fissionable and fusionable

c) Conditions for the fission and fusion of matter are three-fold

i) Causality (*kārana*) ii) psychic activity and iii) eligibility for union

i) Causality is again three fold a) by association (union) b) by disassociation and c) by both i e partly association and partly disassociation

ii) Psychic activities are again three-fold a) *visrasā* i e natural or spontaneous (for which no effort is necessary) b) *prāyogic* i e synthetic and c) partly natural and partly synthetic

iii) Eligibility for union is again three fold a) *paramāṇus* possessing one unit of unctuousness and one unit of dryness will not unite b) *paramānus* possessing opposite *sparsa* of equal and unequal intensities may unite c) *paramāṇus* with similar *sparśa* can unite only if their respective intensities differ by two units or more i e there must be a minimum difference of two units in the intensity of dryness or unctuousness

All forms of matter (including *paramāṇus*) possess the qualities of unctuousness and dryness of varying intensities The minimum intensity is the unit of

intensity, and the intensity possessed by a *paramāṇu* can always be expressed by an integral number and not by a fraction

d) Formation of composite material bodies Elementary particles—*paramāṇus*—combine together and produce composite bodies The simplest composites are made up by the combination of two *paramāṇus* and are called *dvipradesiya skandha* Then there are *tripradesiya chaturpradesiya* etc, made up by three four and so on *paramāṇus* respectively By this process we come to bodies made up of *asamkhya* (innumerable) and *ananata*[76] (infinite) and finally *anantānanta* (infinitely infinite) number of *paramāṇus* respectively called *asankhya-pradesiya ananta-pradesiya* and *anantānanta pradesiya skandha* Jain sages by their profound knowledge of the structure of matter have established that this process of combination of *paramāṇus* and production of *skandhas* follow some definite rules Out of the four innate qualities of a *paramāṇu*, the quality responsible for the combination is (dry and unctuous) *sparsa* [77]

The fundamental condition is that the *paramāṇus* with unit intensity of dryness or unctuousness are not qualified to participate in the composition[78] This means that *paramāṇus* participating in a composition must possess more than unit intensity of dryness or unctuousness

Combination of *paramāṇus* with same as well opposite *sparsa* is possible When two *paramāṇus* possessing same *sparśa* (say unctuousness) combine, the minimum difference between the intensities of

76 *Jains conceive an infinite gradation of infinity*

77 *SNIGDHA-rookstvād bandhaḥ -Tattvartha Sūtra*

78 *Snigdha rookstvād ajagnyagunānām -Jaina Siddhanta Deepikā*, I 17

their unctuousness must be two units[79] Similarly the minimum difference of two units of intensity between dryness of two *paramāṇus* qualify them to combine On the other hand the *paramānus* with opposite *sparśa* i e dryness and unctuousness would combine without qualifying minimum difference between their intensities The 615th verse of Gommatsāra says "An unctuous particle may combine with another unctuous particle with a minimum difference of two units of unctuousness And this also is the rule in the case of dry particles The combination of an unctuous particle with a dry one is always possible be they of the same or different intensities But in all these three the particles possessing the unit intensity i e one unit of each *sparsa* are exeepted "[80]

i) Extension Since *paramānu* itself is a dimensionless point, space occupied by a single free *paramānu* is an indivisible point (space-point) Two free *paramānus* will therefore occupy two space-points But after fusion an aggregate of two *paramānus* may occupy a single space-point An aggregate composed of infinite *paramānus*, if densely packed, may also occupy a single space-point The maximum extension of an aggregate is equal to the number of its constituent *paramānus* The maximum extension of an aggregate with infinite *paramānus* is *asamkhya* and not infinite space-points It must be remembered that a number of *paramānus* may occupy the same space at the same time and may or may not unite

79 *Dvayadhikādiguṇtve sadṛsānām*-*Ibid*, 1 18

80 *Nidhdhassa nidhdheṇa duhāviyena*
Lukhassa lukheṇa duhāviyena
Nidhdhassa lukhena uyeyi bandho
Jahnnavajjo visamo samo vā-*Gommatasāra, Jeevakanda, gathā* 615

Bandha i e union or fusion is two-fold (a) natural and (b) synthetic Natural fusion is again two-fold (a) beginningless and (b) with a beginning

It is two-fold from another point of view viz (a) partial union and (b) total union [81]

Natural union is caused by three conditions

(a) Natural union is caused by the unctuous and dry properties of the constituents—*Bandha pratyayika* (b) Union caused by the contents of a common container—*Bhājana pratyayika* (c) Union caused by mutation—*pariṇāma-pratyayika* [82]

Five different ways of *Bheda* i e fission are

a) bursting i e due to internal forces

b) breaking into pieces due to external forces

c) grinding

d) removal of layers and

e) fissures

VI) MATTER IS *PARINAMI* i e SUBJECT TO MUTATION

Matter is mutable and it undergoes transformation Mutation is change i e change of one state into another Nothing is absolutely permanent nor absolutely destructible [83]

"*Avasthitsya dravyasya poorva dharma nivrtau dharmāntarotpatih parināmah* "(Commentary by Vyas)

Destruction of the preceding state gives way to the birth of the succeeding state

The word for mutation is *parinama* It has been explained in different ways in Jain scriptures In *Rājavārtikam* it is said that *parināma* is natural or artificial mutation of a substance without affecting its

81 Mixture and compound

82 *Bhagavatī Sūtra* 8-9

83 *Pariṇāmo avsthāntara-gamanam, na cha sarvathā vinā- śaḥ Syadvād Mañjari.*

own fundamental identity[84] In order to make a distinction between *pariņāma* and *kriyā*—activity, *Siddhasena Gani* has defined *pariņāma* as mutation other than vibration etc[85]

In the *Tattvārtha sūtra parināma* is defined as the inherent nature and the corresponding activities of each substance[86] Five *parināmas* are listed in the *Bhagavati sūtra* viz., *varna* (colour) *rasa* (taste) *gandha* (odour), *sparśa* (touch) and *samsthāna* (shape)[87] which render the matter sensuous or cognisable by senses Ten *parināmas* of unconscious substance are listed in *Pannavā sūtra* all of which are attributable to matter Five of the ten are the same as in the *Bhagavati Sūtra* and the rest are *Bandha* (association), *bheda* (disassociation) *gati* (motion) *sabda* (sound), and *agurulaghu* (masslessness)

Temporally *parināma* is two-fold i) beginningless and ii) with a beginning[88] *Parināma* of matter is with beginning[89] A *paramānu* in its free state will have two out of ten *parināmas* viz., motion (gati) and masslessness *(agurulaghu)* After uniting with other *paramanus* or aggregates it may undergo other *parinamās* also There are many varieties of *parina-*

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84 *Dravyasya svajatyaparitvagena pravoga visrasa lakshano vikāraḥ parināmaḥ*
Tattvārtha Rājavārtikam 5-22 10

85 *Dravyasya svajatyaparityagena parispandetaru prayogaja paryāya svabhāyaḥ priņāmaḥ—Tattvartha Sūtra, Siddhsena s Commentary*

86 *Tadbhāva pariņāmaḥ—Tattvārtha Sūtra* 5 42

87 *Panchavihe poggala pariņāme paņnatte tan jahā vaņna gandha, rasa, fasa, sanṭhāņa pariņāme —Bhagavati Sūtra* 8 10

88 *Anādirādimanscho —Tattvartha Sūra*, 5 42

89 *Rūpiṣvādimān—Ibid*, 5 43

mas (of matter) with beginning[90] There are three types of aggregates on the basis of causality viz, i) natural ii) artificial or synthetic and iii) mixed

VII) MATTER IS INFINITE (NUMERICALLY)

The ultimate elementary constituent of matter is *paramānu* which are infinite numerically It follows, therefore, that substantially matter is also numerically infinite Maximum extension of matter is *loka* Spatially matter remains in the active universe loka) only and it pervades the total space of the active universe (loka)

VIII) MATTER INTERACTS WITH CONSCIOUSNESS

Matter is attracted (and assimilated) by consciousness, that is interaction is possible between the physical and psychical orders of existence Matter is incapable of imposing itself on the psychical order but is capable of reacting with it once it has been captured by the latter Psychical substance alone has the power to attract and assimilate material bodies thus rendering itself liable to be corrupted by matter (*karmic* matter)

It has already been stated that all the different groups *(varganās)* of matter do not interact with the psyche The eight groups of matter which interact with psyche have been briefly described in the previous section The group which is most intimately associated with consciousness is *kārmaṇa* group or *karma pudgala* The relation between the psychical and the material is so concrete that they become somehow identical in the state of worldly existence By its own nature the conscious substance is always changing But in the state of worldly existence the change is determined by the nature of the *kārmic*

90 *Rupiṣu drvyeṣu ādimān pariṇāmo aneka-vidhaḥ.—Ibid (Bhasya)* 5 43

matter that is associated with it The nature of the *kārmic* matter is determined by the nature of the passions and perversion of the psyche and the intensities of passions etc are again determined by the nature of the *kārmic* matter

The *kārmic* matter associated with consciousness determines not only the nature and intensities of passions but also the life-span, the type of gross body viz *audārika* or *vaikriya*, during the life-span etc The gross body is then the instrument of experiencing happiness and miseries of the worldly existence The material of other *varganās* viz, *svasochchhwas bhāsa*, and *manah* are also essential for the worldly existence

Material *karman(dravya karman)* and its spiritual counterpart (bhāva *karman*) viz, passions and perversities of the soul are thus mutually related as cause and effect, each of the other[91] Thus the assimilated *karman* begets *śarira*, (body), mind and speech and their activities-physical mental and vocal-attract *karmic* matter which then is inseparately mixed up with the soul Only the matter which is fit for the purpose of being transformed by the soul is attracted by it

The space is filled up by the *karmic* matter but only those particles which occupy the same space as the psyche can be caputred by it Passions generated by the interaction of the assimilated matter and the corrupted psyche are the cause of attracting the matter Thus corruption begets corruption (Pure consciousness is free from passions and therefore does not attract corrupting matter)

91 *Dosavaranayor jeeva-pudgala-parinamayor anyonyakārya-kāraṇa-bhāva-inapamarthavat* -*Asṣṭāsahaśri*, p 51

Paramāṇus are not attracted by the soul nor are all kinds of material composites First of all there are the composites-bodies belonging to the *kārmana vargaṇā* which are capable of being transformed as *dravya karman* which obscure and distort the purity of the soul Then there are the composites belonging to other *vargaṇās* which are transformed into *śarīra (audārika, vaikriya* etc), *bhāṣā* (speech), *prāṇāpana* (respiration) and *manas* (mind)

Jain doctrine of *karman* as propounded by the Jain *arhats* gives full details such as the material nature of *karman*, relation between soul and *karman*, classification status and processes of *karman* etc

IV

PARAMANU THE ULTIMATE INDIVISIBLE UNIT OF MATTER

A DEFINITIONS AND PROPERTIES

The canonical literature defines *paramāṇu* in various ways from different angles It is the ultimate particle of matter which is indivisible, indestructible, impenetrable, incombustible and imperceptible to sense organs [92]

It cannot be split by any means whatsoever The sharpest instrument cannot divide it into two and the highest temperature cannot destroy it by burning It does not become wet even if it is drenched by the deluge clouds *(pushakrāvarta mahāmegha)* It will not lose its existence or identity even if it enters a drop of water or a whirpool of water

It is a true point It has no half-portion, no middle portion and no *paradeśa.* It has no length, no breadth and no depth It is demensionless It is the ultimate

92 *Bhagavati Sūtra,* 5 7 6

and eternal unit [93]

It is truly infinitesimal Its beginning, the middle and the end are identical with the whole of itself.[94] Hence the sages have observed that of which the start, the centre and the end is the same i e which itself is the beginning, itself is the middle and itself is the end, that which is not perceptible (cognised by sensual perception) and that which is indivisible is called *paramānu* [95]

In the *Panchāstikāya-sāra, paramānu* is defined by some other characteristics viz., its innate qualities thus 'the substance which has a single taste, a single colour, one smell and two kinds of *sparsa*, which is the cause of sound but is not sound itself, which is not the same as *skandhas* (composite) though constituting them, is the *paramānu*

According to the above definitions, four sense data viz., touch, taste, odour and colour are intrinsic qualities of a *paramānu* Sound, being an attribute of *skandhas* is not associated with *paramāṇu*

The qualities possessed by a *paramānu* are one of the five primary colours, one of the two smells and one of the five tastes and two of the four touches i e either hot or cold and either dry or unctuous

In the commentary to the canons the *paramānu* is defined thus *Paramānu* is the fundamental substance and the cause of formation of aggregates i e it is the ultimate elementary particle in every material object, it is the smallest indivisible particle of matter, it is indestructible, it existed in the past, exists in the present and will continue to exist in the future It

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93 *Tattvārtha Rājvārtika* 5 25 1

94 *Saukṣmyādātmādayaḥ ātmamadhyāḥ ātmāntāścha Tattvārtha Sūtra with Sarvarthsiddhi commentary* 5-25

95 *Ibid*

possesses a single colour, a single odour, a single taste and two touches It can be perceived only by its effects i.e a single free *paramānu* is invisible not only to the naked eyes but also to any other physical instrument Its existence is to be inferred by the collective action and reaction of many *paramāṇus* Only the omniscient *(kevalajñānī)* and those who possess superlative visual intuition *(paramāvadhi jñānī)* can perceive and cognise the nature of a free *paramanu*[96]

Although the four qualities are permanently possessed by a *paramānu* the intensity or the potency of the qualities do not remain constant A *paramāṇu* possessing one unit of blackness at any moment may sometimes later possess two, three or many units of blackness It follows from this that at any given moment there would be *paramāṇus* with different intensities of blackness etc In the same way there would be *paramāṇus* with various degrees of other qualities

Paramānu is the short form of drvya *paramanu*[97] or

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96 *Bhagvati Sūtra* 1818

97 Just as *paramāṇu* is an infinitesimal indivisible unit of matter, the *Bhagavatī Sūtra* 20-5-12 enumerates a) *Dravya paramāṇu* or *pudgala paramāṇu*-infinitesimal indivisible unit of matter

b) *Kshetra paramāṇu* or *Akāsa pradeśa*-indivisible unit of space or space-point

c) *Kāla paramāṇu*-indivisible unit of time or time-point called samaya

d) *Bhāva paramāṇu*or *Guṇa*-unit of intensity of sensuous qualities which are of 4 kinds viz colour odour taste and touch and which are sub-divided into 16

5 colours	Black, white blue red & yellow
2 odours	Good smells and bad smells
5 tastes	Sweet, bitter pungent acidic and astringent
4 touches	Hot cold dry and unctuous

parāmanu pudgala On ultimate analysis thewhole material universe is *paramāṇu.* As we have seen *paramāṇus* have the innate capacity of uniting with one another to form composite bodies The union of *paramāṇus* may be the result of some psychic activity *(prāyogic)* or it may be natural *(vaiśrasika)* The union is subject to certain definite rules as all types of *paramāṇus* are not eligible to participate in the union The composite bodies are liable to the process of decomposition (again subject to rules) and the united *paramāṇus* may become free particles and thus the association and disassociation goes on eternally The *paramāṇu* is the ultimate cause *kāraṇa aṇu* - as well as the ultimate end product - *antya aṇu.*

Kāranameva tadantya sūkṣmo nityascha bhavati paramāṇu

Ekarasa - gandha - varno dvisparśah kāryalingaścha

The above verse defines the *paramāṇu* in the following terms

1 It is *kāraṇa* i e it is the cause of the creation of the material universe
2 It is *antya* i e it is the ultimate end product of the material universe
3 It is *sūkṣma* i e infinitesimally fine
4 It is *nitya* i e indestructible It does not lose its individuality even when participating in a union
5 It possesses one *rasa*, one *gandha* and one *varna*
6 It is *dviśparsi* i e it possesses two *sparśa* either dryness or unctuousness and hot or cold i e it is either dry cold or dry hot, or unctuous cold or unctuous hot
7 It is *kāryalinga* i e it can be cognised by inference only through the effects of collective actions Its qualities can also be cognised through the qualities of the composite bodies In short, by itself it is

not an object of sensuous cognition Only transcedental and extra-sensory perception can cognise its qualities

Let us now see which of the properties of matter which were discussed in detail in the previous section are applicable to *paramānu*

1 *Paramāṇu* is a substance It is *nitya* (eternal) and *avasthita* (untransmutable) This is so because paramanu never loses its identity even though it participates in the union to produce composite bodies Thus nor a single *paramānu* is destroyed nor a new one created The total number of *paramānu* is eternally the same

2 It is *ajeeva*—devoid of consciousness It has a real existence By itself it is not *kāya* because it is solitary However, when united with other constituents of a composite body it is a participant of '*kāya*'

3 It possesses four primary sensuous qualities—colour, taste, smell, and touch but is devoid of *samsthāna* because it has no shape and it has no length, breadth or thickness

4 It is capable of being active and dynamic When mobile it may have vibratory as well as migratory motions The activity of a *paramāṇu* is not continuous but rather in the form of quantas

5 Individually i e by itself it is not fissionable The process of fission and fusion are attributes of composite bodies

6 It is *parināmi* By itself it is *agurulaghu parinami* i e it has no mass The mutation is in respect to its innate qualities viz, colour, smell, etc

7 It can assume a very high velocity, since it has no mass there is no upper limit to its speed[98] It

98 *Eka samaya lokānta prāpiṇām*–*Bhagavati Sūtra Vrtti* 1 6 8

cannot however, cross the boundary of *loka* and *aloka* (since there is no *dharmastikāya* in *aloka*) Since it exists everywhere in the whole *loka*, it can be said to pervade the *loka*

8 By itself it is not attracted by *jeeva* and is therefore not assimilated and does not interact with *jeeva*

B DETAILED DISCUSSION OF THE PROPERTIES OF *PARAMANU*

1 Nomenclature Its full name is *paramānu pudgala* or *dravya paramānu*, but is generaly called '*paramānu* In the following, *paramānu* means *paramanu pudgala*

2 *Substantialty paramānu* is a substance because it possesses both quality and modes

3 Spatially *paramānu* pervades the whole of the *loka* but is incapable of crossing over to *aloka* By itself it occupies a single space-point and can never extend to more than one, a body composed of infinite *paramānus*, compactly packed may also occupy a single point in space

4 Temporally *paramānu* existed in the infinite past It exists in the present and it shall exist in the infinite future Temporally it is eternal

5 Qualitatively *paramānu* possesses colour, taste, smell and touch These four are innate qualities of *paramānu*

   a Colour—*paramānu* possesses one of the five primary colours (black, blue, red yellow and white) More than one colour or a mixture of two or more primary colours does not subsist in a free *paramāṇu* The intensity of the colour possessed by a *paramānu* could be one unit two units and so on upto *(asamkhyāta)* units and even infinite units Colour (and its intensity)

subsisting in each individual constituent *paramāṇu* of a composite body determine the resultant colour of the body

b Taste—what has been said about colour and its intensity in the preceding paragraph holds true about taste also There are five primary tastes viz sweet sour, pungent astringent and bitter

c Smell—there are two primary smells—pleasant and unpleasant For the rest every word of para (a) holds true by substituting 'smell' instead of 'colour'

d Touch—a free *paramānu* possesses anyone of the following four combinations of touches

i) hot and dry ii) hot and unctuous iii) cold and dry iv) cold and unctuous

Heaviness or lightness and softness or hardness are not the innate qualities of *paramānu* These four subsist only in composite bodies with gross structure The intensities of dryness etc possessed by a *paramānu* could be one unit upto infinite units

6 Quantitatively—*paramānu* is indestructible The total number of *paramānus* in the universe never changes Not a single *paramānu* is destroyed—not a single new one is created Under all circumstances and for all times the total remains constant

7 Metaphysically—*paramānu* is real It is subject to the principle of permanence-through-modes and therefore has an objective real existence It is neither a figment of mind nor is merely a postulation

8 Geometrically—*paramānu* (by itself) is shapeless But it is not *aroopi* It is a true point and therefore has neither length nor breadth nor

thickness Shape is quality of composite bodies

9 Transmutation—not a single *paramānu* can be destroyed or transmuted into another substance nor another substance be transmuted to create a new *paramānu* But *paramānus* combine together to form composite bodies and the latter may again dissociate into *paramāṇus*

10 Roopatva—though *paramāṇu* is beyond sensible cognition it is *roopi*, it is not *aroopi* because it possesses sensible qualities of colour, etc and when synthesised in a composite body it acquires the quality of *samsthāna* (shape) also

11 Classification—on the basis of the four innate qualities of *paramāṇu* there are $(5 \times 5 \times 2 \times 4) = 200$ primary classes of *paramanus* And on the basis of intensities of these qualities, there would be infinite sub-classes of each of these 200 classes

12 *Parināma* (mutation)—*paramānu* being a substance undergoes mutation Its four innate qualities viz, colour, taste, smell and touch undergo mutation By itself it is shapeless and in the free state it does not assume any shape In the free state all mutations are of the *visrasā* type i e self-generated Also in the free state the mutation is only in the intensities of colour etc, i e X unit black changes to Y unit black but black does not become white or red etc but during and after union with others, change in colour (black changing to blue) etc, may also take place

13 Agurulaghu—*paramāṇu* is *agurulaghu* i e it is neither heavy nor light This is another way of emphasising that it has no mass The qualities of *gurutva* and *laghutva* are acquired later by

composite bodies of certain groups and structures

14 Permanence-through-modes—*paramāṇu* as a substance is indestructible and therefore permanent or eternal But from the point of view of its qualities which undergo modifications it is changing That is why it has been called permanent as well as impermanent [99]

15 Interaction with psychic substence—*paramānu* by itself that is in its free state is not attracted or assimilated by jeeva[100] and therefore serves no useful purpose[101] for the psychic existence

16 Unity-multiplicity—*paramānu* is a primordial unity It has an eternal existence of its own which is determinated by its own qualities and modes Paramanu as a substance is not a composite body it is truly indivisible unity But as a substratum of many qualities it does possess multiplicity Spatially again because it occupies a single space point it is unity

17 Kriyā (action) and gati (motion)—*paramānu* is active and dynamic It is not always active or always dynamic Sometimes it is and sometimes it is not Its actions are subject to the rule of uncertainty Paramānu is capable of a variety of actions

The *Bhagavati Sūtra* (5-7-150) describes the variety of actions of a *paramānu* [102]

Paramānu sometimes merely vibrates without leav-

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99 *Siyā sās sae siya asāe-Bhagavati Sūtra* 14 4 5

100 *Agrāhya-Ibid* 20 5 13

101 *Ibid* 18 4 1

102 See P 73 above

ing the space-point occupied by it [103] It sometimes migrates i e goes from one space-point to another It sometimes vibrates and migrates simultaneously It executes linear motion while continuing to vibrate Both (vibratory and migratory) motions could be simultaneous All those motions are temporally regular as well as irregular

Paramānpu is self-activated i e becomes active without any outside influence and also under the influence of other *paramānus* or composite bodies but the psychic substance *(jeeva)* can not influence the activity of a single *paramānu* This is so because a *paramānu* is never attracted by the activities of a *jeeva*

At what speed does a *paramāņu* move? at what frequency does it vibrate or if it revolves at what rate? We do not find any information on the rate of frequency of vibratory motions But it is clearly mentioned in the *Bhagavati - Sūtra* (16 8 7) that a *paramāņu* can move from one end of the *loka* to the other in one time-point This is of course the maximum velocity of a *paramāņu.* Its minimum velocity is one time-point for its linear motion from one space point to the adjacent one

Whether it moves to an adjacent space-point or crosses the whole *loka* from one end to the other if the time taken is a *samaya* the motion will be in *anusreņī* i e straight and without turning If there is a bend, the time will be more than one *samaya* Bending is always due to external forces

103 A question arises 'how can a *paramānu* move without leaving its rest-point' Vibration as we know necessarily implies change of space-points A thing may revolve round its own axis But how can there be an axis when *paramāņu* is an indivisible point?

From the above it is clear that in some respects *kriyā* and *gati* of *paramānu* follow definite rules while in other respect they follow the principle of uncertainty[104] We can summarise the definite rules as under

1 Unless acted upon by external forces *paramāṇu* moves in a straight line *(anusrenigati)*
2 When acted upon by external forces *paramānu* may change direction and speed
3 *Jeeva* has no direct influence on the motion of *paramānu*
4 Minimum and maximum distances travelled by *paramānu* in one *samaya* are, space between two adjacent points and the entire length of the *loka* respectively
5 Maximum period of inactivity (rest) is *asamkhyata samaya* Maximum period of activity is *asamkhyatath* portion of an *avalika*

On the other hand the principle of uncertainty governs the following

1 It is uncertain, after what interval of time will a *paramāṇu* at rest will become dynamic (release energy) This time-interval may be from one *samaya* upto innumerable *samayas* However, after an interval of innumerable *samayas* it will become active for sure
2 Similarly it is uncertain upto what duration of time will a dynamic *paramānu* continue to be active It (the duration) could be from one *samaya* to an *asamkhyātath* portion of an *āvalikā*. But it will surely cease to be active after this maximum interval
3 It is uncertain, which direction will a *paramāṇu* take at the commencement of motion It can move

104 *Paramāṇorgati aniyatā-Tattvartha Rājvārtikam*

in any possible direction

4 It is uncertain, what type of dynamic activity will be commenced by an inactive *paramānu*, it may just vibrate or rotate or migrate or do all these things simultaneously

5 It is uncertain again what will be the intensity of a *paramānu's* dynamic activity what will be its velocity—minimum or maximum or intermediate?

APRATIGHATI

Paramānu is entirely *apratighāti* i e it cannot be stopped retained or hindered by anything At the same time it does not cause hinderance to others This means that

i) The motion and activity of *paramānu* cannot be stopped or restrained by another material body or *jeeva* A *paramāṇu* in motion is capable of penetrating and passing through any type of obstruction in its way

ii) A *paramānu* can occupy a space point which is already occupied by others *(paramānu,* composite bodies or *jeeva)*

iii) A *paramānu* can commence and continue its own motion and activities irrespective of the other occupants of the same space

iv) A *paramānu* can leave the occupied space without any restraint from the other occupants

Inspite of possessing the unique quality of *'apratighātitva'* as defined above the *paramānu* is subject to pratighat (hinderance) under the following conditions

1 *Upkārabhāva pratighāta* (restriction due to the absence of media)— It cannot penetrate the boundaries of *loka* and cross over to *aloka* This is because there is no *dharmāstikāya* in *aloka* and without the aid of *dharmāstikāya* nothing can move And so the

paramānu on reaching the boundary of *loka* is stopped and may be thrown back

2 *Bandhana-parinām-pratighāta* (restriction due to association)—It loses its free state and the capacity for independent activity for the time being, when it is united with other *paramānus* i e so long as it remains a constituent of a composite material body

3 *Ati-vega-pratighata* (restriction due to high velocity)—Collision between two self-activated *paramānus* moving at a high velocity may cause *pratighāta* in the motions of both

CHAPTER III

A CRITIQUE

INTRODUCTORY

In[1] the orient, science became a part of religion, and the two got so much mixed up that it was impossible to extricate one from the other But in the West, they remained in hostile camps, poles apart Even now, according to scholars like A Toyanbee and others, there is no compromise between the two

Modern science in the West was born around the 12th centruy A D on the basis of inspiration it received from the Greek philosophers who had lived about 2500 years ago and who had provided 'reasoning' But the immediate impetus was provided by the quest of 'truth' which was enshrouded in and discouraged by teachings of the dominant church The Copernican theory shook the most basic theological and philosophical canons of the day It proved the intellectual spark for the tremendous acceleration of knowledge Under the prodding of Galileo Kepler Newton and others questions of nature were thrust directly into the combative public arena of empirical inquiry Experiments became crucial and theories had to be supported by close observations Thus the scientific method stressing reasons and logic was born So modern science started in the west by breaking away from the church teachings and since in the ensuing battle, science proved the stronger of the two it dominates the western life today more than the church

In India, the ancient Jain and other savants engaged themselves in what may appear to westerners, conjectures and speculations about the origin of matter and material universe based on their spiritual

1 *Jain Journal* Calcutta

insights One would search in vain for the use or description of scientific apparatuses in the Jain canonical literature because these were not developed at that time What then was the source of their knowledge and spiritual insight? It appears that the capacity of profound thinking (resulting from severe austerities), uninterrupted concentration of thought and meditation enabled the ancient sages to acquire transcendental and extrasensory perceptive powers The practice of meditation——*DHYANA* —— was accorded a very high priority in their daily routine and deep concentration became an easy and effortless achievement It has been claimed that most difficult problems can be solved by the process of meditation, and it is not very difficult for us to accept this claim as we know that the modern great philosophers, scholars and mathematicians were nobodies if they were not great thinkers

In the mediaeval period there flourished many Jain scholars, whose interests were wholly literary or spiritual Even though they contributed a great deal in the fields of mathematics logic and perhaps astronomy, their contribution to the growth of scientific knowledge was almost negligible In the meantime, modern sciences had become firmly established by a wholly independent growth in the West And now, science is almost wholly put to a material end, thereby removing any plausible basis for comparison between modern science of the West and traditional knowledge of the East It is therefore extremely difficult to adjudge how much scientific the Jain thinkers have been or how far from it But the Jain scholars did develop an adequate methodology and an admirable terminology for the presentations of their findings which one is free to accept or reject

[2]It is probably true, quite generally, that in the history of human thinking the most fruitful developments frequently take place at those points where two different lines of thought meet These lines may have their roots in quite different parts of human culture, in different times, different environments or different religious traditions, hence if they do meet, that is if they are at least so much related to each other that a real interaction can take place, then one may hope that new, interesting and useful developments will follow The purpose of the following discussion cannot be to make predictions but it may be possible to define some points from which the interaction between the ideas of modern science and the older tradition may begin

METAPHYSICAL VIEW

We have already seen that the non-absolutist realism of the Jains neither endorses absolute eternalism nor absolute nihilism but explains both these extremes as real with reference to different aspects of the same reality Thus mutation (change) is as much real as permanence A substance is a substratum of infinite qualities Nothing can exist without being in some determinate way and the qualities of a substance means its existence in a determinate mode of being Thus, assert Jains, the qualities cannot be absolutely different from the substance nor can they be absolutely identical with it

We have also seen that matter (called '*pudgalāstikāya*' by them) is the only substance which can be the object of sensuous cognition At the same time we have seen that *paramāṇu*, the ultimate elementary particle of matter and some kinds of material aggre-

2 W Heisenberg, *Physics and philosophy*

gates cannot be perceived by sense organs Nevertheless all modifications of matter, be it a single free elementary particle (*paramānu*) or an aggregate composed of infinite number of elementary particles do possess the four qualities of touch, taste, smell and colour These qualities are also real and their existence does not depend upon the percipient Besides these four innate qualities, matter possesses innumerable other qualities which are all subject to incessant series of modes

With these views, it is obvious that Jains will refute all types of philosophical idealism, subjectivism and solipsism Being non-absolutists however, Jains will almost always find points of agreement in the views of most schools of thought We shall, therefore, compare Jain views with those of a few Western philosophers and scientists with particular reference to the existence of physical reality

Beginning with Kant, while it is admitted by Jains that there is a difference between the 'thing-in-perception' and the 'thing-in-itself', it is partly due to the limitations of sensory power and partly due to the intervention of sensory equipments and not due to any change in the objective existence of the qualities themselves In this respect therefore they do not accept Kant's doctrine of thing-in-itself completely [3]

Jain realism, obviously, does not accept the doctrine of Berkeley (the archenemy of realism) etc., generally known as empiricism according to which things (material objects) do not exist until they are perceived 'The esse of the thing is merely percipi'

3 For detailed discussion, see, Muni Shri Mahendra Kumarji *'Dviteeya'*, *The Theories of Reality* in *the Philosophics of the Jains, Western Philosophors and Scientists*

as Berkelev is fond of putting Berkeley takes recourse to divine assistance to reconcile his theory with the common sense conviction that things do not cease to exist when our perception is discontinued and also the fact that we cannot perceive what we please and where we please He explains the continuity of the physical existence by saying that God produces perception in a fixed order and that when our perception is discontinued, God continues to be aware of things

Jains accept the existence of an omniscient experience i e a perfect and absolute apprehension of the whole reality which is presented as it really is in its completeness or rather the whole is presented at once in its entirety Notwithstanding the apprent similarity, there is a fundamental difference between the two views Whereas Berkeley asserts that the existence of the physical order is dependent on its being perceived by God Jains believe that the existence of things is real and independent of perception, things are perceived because they exist [4]

Sir Arthur Eddington an eminent physicist calls his philosophy selective subjectivism and asserts that it is quite different from solipsism and Berkeley's empiricism He makes a distinction between the actual existence of the external world and 'our experience' of the same Thus 'in so far as we can separate the subjective and objective elements in our experience the subjective is to be identified with the physical and the objective with the conscious and spiritual aspects of experience.' This means that though the material world exists it does not appear in our experience or observational knowledge Thus, although he accepts the objective existence of matter

4 Cf Ibid

in the realm of metaphysics, he denies such status to it in the realm of epistemology because he does not accept that sensory qualities exist objectively in matter

This is in opposition to the Jain view Jains argument in rebuttal to Eddington's view is 'if it is the consciousness that creates sensory qualities and if the matter itself is devoid of these qualities, how can a single object be perceived identically by different percipeints with normal sensory equipments?'[5]

Sir James Jeans, another eminent physicist, is also a supporter of philosophical idealism According to him 'the objective and material universe consists of little more than 'construct' of our own minds The universe is created by a pure mathematician who does not concern himself with material substance but with pure thought His creations are not only created by thought but consist of thought In his views both subjective and objective fall within what is inside our minds '

It would be rather difficult to compare Sir Jeans' views with Jain views because unfortunately his presentation of his own views is extremely ambiguous and obscure However we may try to do so on the basis of our interpretation of his views

Jeans has accepted the reality of mind (psyche), which according to him is a non-mechanical reality The Jain philosophy asserts that soul is a non-physical reality Thus 'mind' of Jeans and 'soul' of the Jains being non-mechanical in nature, describe the same reality Jeans, however, has not explained the nature of the structure of the non-mechanical reality (i e mind) and therefore, we are not in a position to compare his concept of mind with the

5 C f *Ibid.*

Jains' concept of soul Jeans, of course, talks of 'Universal mind' and 'individual minds' The Universal mind, according to him, is the creator and governor of the realm of matter as well as the individual minds He believes that atoms out of which our individual minds have grown exist as thought in the Universal mind

The Jain view does not agree to the existence of any such Universal mind of which the individual minds are units of excrescences According to the Jain view, all the souls are independent individual entities having real objective existence Jeans has not given any reason for his belief which is akin to the pantheistic view

Jeans believes in the existence of God as the creator of the Universe For 'God' he uses the terms 'Great Architect of the Universe' Also Jeans believes that the Great Architect of the Universe must be a pure mathematician As we have already seen, the Jaina philosophy does not concede to the theory of universe as a creation of God It contends that the universe is a collection of the eternal and everchanging realities, and is, therefore, not a creation (of any mind)

Now as we have already seen the Jain view concedes that the sensory knowledge of the phenomena of the universe may not be wholly objective,[6] but it does not conform with Jeans' views in considering the phenomena of the universe as wholly subjective

According to Jeans, the objective reality or the real essence of substance is beyond our knowledge He, thus, seems to accept Kant's transcendentalism in which the thing-in-itself is considered to be tran-

6 See, *ibid*,

scendental We have already compared Kant's view with the Jain view and need not repeat here the whole discussion. In brief, it can be said that the Jain philosophy also declares that the ultimate essence of substances cannot be comprehended through the sensory knowledge and hence at least in this aspect, Jeans' view is consistent with the Jain view

Lastly we shall discuss the concept of substantiality Jeans defines 'substantiality' as a 'purely mental concept measuring direct effect of objects on our sense of touch' Now if it is so i e if substantiality is not inherent in the substances how do the objects (or substances) exist without substantiality? Also Jeans' discussion of the degrees of substantiality is not only equivocal but almost absurd On the other hand, the Jain philosophy furnishes us with the crystal clear definitions of the terms substance substantiality etc and proves objectiveness of substantiality on logical and empirical grounds Substantiality as a purely mental concept is definitely not acceptable to the Jain philosophy Thus both views vehemently differ from each other on this point [7]

Some other scientists Weyl Mach and Poincare are also denying the objective existence of the material universe Weyl's views are very much similar to Sir Eddington's selective subjectivism In Mach's view even the atom is only a construct and in Poincare's view it is impossible that a wholly objective world can exist [8]

It would be interesting to compare the eminent philosopher-scientist Sir Albert Einstein's views supporting the Jain's philosophy's assertion regarding the reality of atom and the objective existence of the

7 See *ibid*,

8 See *ibid*,

external world

"The agreement of these considerations with experience together with Planck's determination of the true molecular size from the law of radiation (for high temperatures) convinced the sceptics, who were quite numerous at that time (Ostwald, Mach)of the reality of atoms The antipathy of these scholars towards atomic theory can indubitably be traced back to their positivistic philosophical attitude This is an interesting example of the fact that even scholars of audacious spirit and fine instinct can be obstructed in the interpretation of facts by philosophical prejudices "[9]

The dialetical materialism also very strongly refutes the doctrine of idealism saying 'the new physics strayed into idealism by ignorance Denying the properties of matter they ended in denying matter itself i e the objective reality of the physical world Insisting on the approximate and relative character of our knowledge they ended in denying the existence of object independent of the mind ' It supports and corroborates the realist view saying the concept of matter epistemologically implies nothing but objective reality existing independently of the human mind Electrons, ether etc exist as objective realities just as nature existed prior to man and organic matter The absence of any other kind of mass in the electron except electromagnetic mass the fact that the mechanical laws of motion are confined only to a single sphere of natural phenomena and are subordinated to the more profound laws of electromagnetic phenomena corroborate the objective existence of matter The electron is to the atom as a full stop is to the size of a building 200 ft long, 100 ft broad and

9 Albert Einstein Philosopher-Scientist

50 ft high (lodge) it moves with a velocity as high as 270,000 kms per second its mass is a function of its velocity, it makes 500 trillon revolutions in a second All this is much more complicated than the old mechanics, but is nevertheless movement of matter in space and time Human reason has discovered many amazing things in nature and will discover still more, and will thereby increase its power over nature But this does not mean that nature is the creation of our mind or of an abstract mind i e of Ward's God[10]

We have concluded that the Jain realism does not accept philosophical idealism It should not however, be assumed that all realist views are acceptable to Jains

Let us compare for example the views of the so-called materialists with the Jains view Both agree in accepting the objective realism as well as the sensible qualities of matter 'Matter is a philosophical category designating the objective reality which is given to man by his sensations and which is copied, photographed and reflected by our sensations while existing independently of them ' This definition of matter given by the materialists comes very close to the Jain definition of *pudgala* viz '*pudgala* is that which possesses in itself the qualities of touch taste colour and odour even though the Jain philosophy denies the possibility of direct perception of the ultimate atoms *(paramānu)* of matter through sensory means it accepts the quality of '*murtatva* being objectively existent even in *paramānus* Also both recognise matter as an objective reality In the words of Lenin 'the sole property of matter with whose recognition philosophical materials is bound up is the

10 *Materialism and Empirio-criticism*, pp 184-85

property of being an objective reality, of existing outside our mind

The fundamental difference between the two views is regarding the ultimate reality of consciousness While the Jains assert its independent existence, old materialists consider it to be identical with matter Though dialetical materialism considers mind and matter to be different, mind (or psyche) is not attributed the status of an ultimate reality

It is quite clear from the discussion in the preceding paras that according to the Jain view physical order of existence *(ajeeva)* and psychical order of existence *(jeeva)* are entirely different substances Consciousness is the characteristic of *jeeva* (psyche) and therefore *ajeeva* is devoid of consciousness Cognitive experience is the most important facet of consciousness and only *jeeva* is capable of a cognitive experience Besides passions emotions, sensation of pleasure or pain, memory experience etc., are various manifestations of consciousness alone Matter is devoid of consciousness and is therefore *ajeeva*

Mutual transformation within the two orders of existence is according to Jains, absolutely impossible Matter, being entirely devoid of consciousness cannot under any conditions, be transformed into *jeeva* The greek atomists believed that psychical order was created and composed of certain types of atoms (spherical, dynamic and smooth) Dialetical materialism does not accept the separate existence of psychical order at all According to it the entire existence is transformations of matter The scientists' views are divided on the subject Some of them accept the independent existence of two orders while some of them agree with the views of the dialetical materialism [11]

11 Cf Muni Shri Mahendra Kumarji op cit

11 INNATE QUALITIES OF MATTER

A) THE WORD *PUDGALA*

The almost exclusive usage of the word *pudgala,* derived from *pud* = fusion and *gala* = fission, emphasises the Jain sages' deep insight into the structure of matter The discoveries of immense sources of nuclear energy have thrown the words fission and fusion into popular limelight But quite apart from this comparatively recent knowledge of the nuclear physics we have seen that there are innumerable instances of both fusion and fission of matter even in everyday life Both are essential whenever energy is released as in the common case of lighting of the match-stick The cellulose of the match fissions into its components of carbon and hydrogen which are then fusioned with the oxygen of the air, to burn and release the chemical energy the same thing happens when the coal catches fire The continuous processes of emission and absorption by the radio-active elements are also example of self-activated *pud* and *gala* Use of this unique property of the substance in its nomenclature reveals the profoundness of knowledge

B) DEFINITIONS

According to the Jain canonical literature, every *paudgalic* (material) object does possess colour, taste, smell and touch Conversely matter is the only substance which is the object of sensuous cognition The other five substances are devoid of sense-data Thus only matter is *'rūpi'* while the others are *'arūpi* The term *rupi* does not mean visible but perceivable and signifies the concurrent existence of all the four sense-data The physical order of existence, accord-

ing to the modern science, comprises of all sensible existence i e existence of the same kind that perceived by the senses, whether actually so perceived or not Thus the Jain views broadly agree with the modern science in so far as the general definition of the physical existence is concerned

C) CHARACTERISTIC PROPERTIES

The objective and simultaneous existence of the qualities of colour, taste smell and touch in *pudgala* has been amply emphasised in the previous section Five elementary colours five elementary tastes, good and bad smell and four elementary touches—hot cold dry and unctuous—makes a total of 16 varieties of characteristic innate qualities of all classes of matter [12]

(I) COLOUR

First of all we should clarify what is the meaning of the statement 'colour etc, are innate qualities of matter Now what is colour? It is some structural peculiarity of a material object which interacts with light and makes the object visible and perceivable by the sensory equipment of vision

Modern science explains the phenomenon of colour on the basis of the wave theory of light According to it, the normal white light from the sun contains the whole visible spectrum When white light falls on any material object it absorbs some of

12 This division of colour into 5 primary types agrees perfectly with the scientific views For instance Colorimetry Committee of the Optical Society of America reported in 1922 as follows

"Colour may be exemplified by the enumeration of characteristic instances as red yellow blue black and white "

Omission of salty from the list of primary tastes is not properly understandable The division of smell appears to be very arbitrary

the radiations and reflects the rest The reflected radiations reach our eyes and we perceive the colour of the object corresponding to wave-lengths of these radiations Thus, when the light from the sun falls on the grass, it absorbs radiations of all other wave-lengths except one representing green colour Consequently only radiations of wave-length representing green colour reaches our eyes They stimulate the optic equipment and we see the grass as 'green'[13]

It is obvious that the reflection of the wave-lengths corresponding to green colour and absorption of the rest of the wave-lengths by grass is due to its own specific structural property Thus, on the basis of the scientific theory of colour, it becomes clear that the perception of grass as green (or rose as red) depends upon the fact as to which wave-length is reflected and not absorbed by the object and this, in turn, is decided by something inherent in the object—some structural peculiarity of the object itself

The Jain view regarding colour is similar to the above Sense-organ 'eye' does not come in direct contact with the object but perceives through the medium of light That is, the perception of colour is the result of the interaction between the inherent quality of colour possessed by the object, light and the sensory equipment Expressed symbolically

C_p denotes the colour perceived,

and C_o denotes the objective colour,

and L denotes the function of light

and S denotes the function representing sensory equipment, then $C_p = f(C_o \ L \ S)$

The green colour of the grass is the colour

13 It may be noted that a body which reflects all of the radiations will appear white while one which absorbs all of the radiations will appear black

perceived by us (C_p) which is created in two steps, firstly, there is an interaction of light (L) with the objective colour of the grass (C_o) and secondly, the resultant products interacts with the sensory (optical) equipment (S) Thus all the three factors—the object, light and the subject (sensory equipment)—play an important role in the formation of perceived colour If anyone of the three factors gets slightly changed, there would be a corresponding change in the perceived colour Thus for example

1) A sees Grass in white light as Green
but A sees Rose in white light as Red (Example of change in object)
but A sees Grass in white light as Green
2) B sees Grass in white light as Red (Example of change in the observer B is colour-blind)
3) A sees Rose in white light as Red
but A sees Rose in yellow light as Orange (Example of change in light)

RAMAN'S STUDY OF COLOUR

Sir C V Raman, the famous Indian scientist and a nobel laureate, has made an intensive research on the phenomenon of colour His findings published in 'Current Science' as series of articles entitled 'The New Physiology of Vision' corroborate the Jain view that it is the internal structure of the material object which is responsible for producing colour He concludes thus

"It follows that all aspects of vision including the perception of space and form, the perception of luminosity and the perception of colour, can only be understood in the terms of the corpscular concept of the nature of light" Again he clearly states "Colour

14 Muni Shri Mahendra Kumarji '*Dviteeya*' *op cit*

as seen in daylight is the sensation resulting from the synthesis by the eye of the whole spectrum of radiation falling upon the object and returned to the eye after scattering or diffusion by the material of which it is composed"

Thus we may conclude that according to Raman the chromatic sensation (i e the perceived colour or C_p in our notation) depends upon the energy of light corpuscles reflected or transmitted by the body, is dependent on some peculiar property inherent in the material of the body and therefore the quality possessed by the material of the body is the deciding factor in the perception of colour It should be noted that the perceived colour (C_p) is not identical because 'C_p' is a function of C_o, i and s

We may summarise the above discussion thus -

The difference in emission and absorption of light by different coloured surfaces is the effect of some innate quality in the material object and light acts merely as a medium for the perception of the colour and not for its existence [15]

From the above discussion we can get a fair idea of the characteristic quality called colour which, according to Jain view, is an inseparable innate property of all material objects

'COLOUR' IN COSMOLOGICAL STUDIES

Colour, one of the four inherent qualities of matter has been a boon to inquisitive mankind in general and scientists in particular More than that, it has been the cause of many spectacular advances in some of the sciences (and even arts) Astronomers in their quest of knowledge of the universe are able to probe

15 Cf *ibid*

and pry into the macrocosmos and see millions of distant stars and galaxies which are thousands of millions light years away With the growth of knowledge from their insights astronomy developed a whole new kind of study called astrophysics The science of spectroscopy became an indispensable branch of astronomy On its findings are based all the modern theories about the universe

The secrets of the universe are written largely in light and can be known by deciphering light itself Everybody knows that white sunlight bent apart by a prism[16] becomes a rainbow of all the colours This is called a spectrum It was found many years ago that the sun's spectrum was not a perfect rainbow but slashed by many dark lines but nobody knew what they meant at that time Later studies showed that light emitted by elements at very high temperatures showed bright slashes in their spectrum Today the knowledge of atomic theory and the true nature of light has established that each element or kind of atom can emit and absorb energy only at the specific wave-length determined by its atomic structure Its pattern may have many lines or a few but its position on the spectrum is always the same and unlike that of any other Thus every element can reveal its identity by its spectral line signature written by the ink of its own unique colour or the fingerprint of its individual personality

The discovery of Helium, christened as the sun element, by its discoverer Sir Joseph Normal Lockyer, about a hundred years ago was the result of the accurate interpretation of the sun's spectral lines with elements in its atmosphere Indeed, the white

16 The prism is now replaced by a more efficient light-splitting instrument viz., diffraction gratings of lines closely ruled on glass

radiance of the cosmos shattered into its component colours can reveal the identity of atoms pulsating thousands of millions of miles away Over the years the spectral lines from a star proved to hold amazing quantities of information the composition of the star, the speed of the star moving towards or away from us, the speed of its rotation, temperature of its surface, the strength of its magnetic field etc Stars are no longer pin-points of inscrutable light but objects with individual personalities

All this is possible because colour is an inherent quality of matter Stars emit coloured lights and each star can be pictured as a colourful spectrum which is its finger-print Its composition is found by identifying the patterns of lines that its chemical elements cast across its spectrum The speed of a star moving towards or away from us is indicated by the so called 'Doppler effect' or shift of its spectral lines The shift is towards the blue, (or left) end of the spectrum if the star is advancing, towards the red (or right) if receding The greater the star's speed the more its lines shift The amount of shift is calculated by comparing the lines with those of a laboratory specimen

(II) *SPARSA* (TOUCH)

The quality of *sparśa* (touch) is also of great importance It should be carefully noted that besides the four *sparśa* given above which are inherent in all states of matter there are four additional *sparśa* viz ,heavy, light, hard and soft or (sometime rough and smooth) which are acquired by certain types of composite bodies Thus there are two classes of material objects (i) *chatuhsparsi* and ii) *aṣṭasparsi* Out of the eight *varganās*[17] (groups) of *pudgala* which

17 See pp 58-61 above

interact with the psychical existence the last four are *chatuhsparsi* while the first four are *aṣṭasparśī*

The qualities of dryness and unctuousness play a very important part in the formation of material bodies and we shall discuss this important quality in greater detail later when discussing the primary qualities of *paramāṇus*[18]

Sir James Jeans defines substantiality as a purely mental concept measuring direct effect of objects or our sense of touch This underlines the importance of the quality of touch The qualities of hotness and coldness are equivalent to the property of temperature in science *Chatuhsparśī*– bodies will, therefore, be dry & hot or dry & cold or unctuous & hot or unctuous & cold Heaviness and lightness are indicative of the mass of the bodies Hardness and softness (roughness and smoothness) indicate the condition of the surface of the body to the sense-organs of the touch The last four types of *sparsa* are acquired by *aṣtsparsī* bodies only *Chatuhsparsī* bodies are therefore devoid of mass

(III) SMELL AND TASTE

By virtue of their inherent quality of smell material objects can be perceived by the olfactory organs There are infinite varieties of smell but they are broadly divided into two categories (i) pleasant and (ii) unpleasant Smell is an important attribute of matter for the *trindriya*—creatures having three sense organs The scientific view of smell is that there are volatile components in the composition of material objects, which stimulate the olfactory organs of living beings Like colour, smell can be split and analysed by gas chromatographic and mass

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18 See pp 143–45 below

spectroscopic methods For instance, roasted coffee is found to contain as many as 100 or more volatiles which together give the characteristic pleasant aroma of coffee

Unlike smell taste is not given 'out' by matter The object itself has to come in intimate contact with the sense-organs of taste As in the case of other qualities there are infinite varieties of taste which can be grouped together to form five categories The taste of any object is the resultant of all different tastes possessed by its composing elements

III CLASSIFICATION

We have already said that according to Jains, material objects are composed of elementary particles called *paramānus* There are infinite types of matter and because they are capable of infinite mutations the entire material universe is infinitely infinite The fundamental reason for the infinite variety is the infinite multiplicity of the four innate qualities, colour etc , of matter and the difference in the number of *paramānus*

According to the modern science also there are infinite varieties of organic and inorganic compounds constituted by various combinations of about 100 different kinds of chemical elements The atoms of the elements are 'different from one another because of the difference in the number of their constituting elementary particles viz protons and neutrons in the nucleus of the atom and the electrons orbiting round

The infinite variety, however, can be grouped together from various aspects to form a few classes or types Thus the entire material universe can be divided into two or three types e g ,

By Science

i) Inorganic	ii) Organic
i) Solids	ii) Fluids
i) Elements	ii) Compounds
i) Atoms	ii) Molecules

By Jains

i) *Viśrasāpariṇata*	ii) *Prayoga-pariṇata*
i) *Bādara* (gross)	ii) *Sūkṣma* (fine)
i) *Paramāṇus*	ii) *Skandha*

By Science

i) Solids ii) Liquids iii) Gases

By Jains

i) *Paramāṇu* ii) *Pradeśa* iii) *Skandha*

Classification of matter by Jains into 23 groups called *varganās* in general and the matter belonging to 8 groups which interact with and serve useful purposes for the living beings in particular merits further examination

Five out of the eight groups viz., i) *Audārika* 2) *Vaikriya* 3) *Āhāraka* 4) *Taijas* and 5) *Kārmana* groups go to make five different kinds of gross and subtle bodies (*śarīra*) for the living beings The first two kinds are gross bodies and the remaining three are subtle ones

Material of the *audārika* group is composed of all the organic and inorganic objects that we encounter in our ordinary life All the necessities of our daily life, food, clothing and shelter are made up from the stuff belonging to this group Our own bodies and the bodies of all animals and plants, in fact of all living

organisms known to us, organs such as brain, heart and stomach, tissues of skin, muscle etc., and the biological atoms called cells are all made up from the *audārika* group When the life becomes extinct the lifeless body that is left behind is *audarika sarira* it either becomes food for some living beings or else rots putrefies and decomposes into its constituents*

Bodies of celestial and infernal beings are made up from *'vaikriya'* group The traditional Jain term for the word 'celestial' beings is *devas* or heavenly people According to the Jain belief, sun, moon, stars etc., are one of the four categories of *devas* viz., *jyotiśka deva* meaning light-radiating or luminous *deva* The life-spans of *devas*, though very very long compared to human beings are nevertheless finite and at the end of the life span a soul of *deva* leaves his lifeless *vaikriya* body behind It is however believed that the stuff making up the *vaikriya* body does not rot or putrefy like the *audārika* body but disintegrates rapidly into its components A *vaikriya* body does not cast a shadow

Science also considers sun, moon, planets and stars celestial or heavenly bodies Sun is nothing else but a star, planets are members of the solar family and revolve round it in definite orbits and moons are satellites of the planets So the most important heavenly bodies are stars And they are no longer pin points of inscrutable light but objects of the individual personalities Stars are 'born' and they 'die' Their life span is of the order of 50,000 to 1,00,000 million years Our sun, for example, was born some 5000 million years ago and quickly came to age assuming the characteristics it has today For another

5000 million years it will continue to be in the prime of life After that it will expand and burn away fiercely for 2000 million years and begin to shrink and decline to a long old age After 50000 million years it will have turned black and heatless i e dead The bodies of the star are made up of primordial gas and dust, more than half of which is hydrogen which is transformed into helium by nuclear fusion The process of nuclear fusion converts matter into energy which is radiated The amount of hydrogen steadily decreases while that of helium increases When the entire stock of hydrogen is used up there is nothing to burn The star becomes black and heatless and dies Thus the life span of this celestial object starts from a cloudy birth and ends into frozen extinction Thus, if the star is a *jyotiṣka deva*[19] then the stellar dust is the stuff belonging to the *vaikriya* group

Ahāraka sarīra is not a common body It is very occasionally created by learned sages only *taijas śarīra* and *kārmana sarira* are the supersubtle bodies assimilated by every soul from the stuff of the appropriate group They are permanent companions of the soul, and are abolished only if and when the soul is emancipated *taijas sarīra* is the link between the soul and the *kārmana sarira* It is the source of energy required by the vital processes of all living organism As its name suggests, *taijas* stuff is probably electrical (or electromagnetical), and the electrical characteristic manifested by the bodies of living organisms are caused by the *taijas śarira*

We have briefly described the functions of *kārmana sarira* in the previous chapter and we can hardly

19 This statement should not be construed as a belief of the Jains nor that of the author It is merely a conjecture emanating from circumstantial similarities

add anything more here because it is extremely difficult to compare these groups with anything discovered by the modern science

The stuff belonging to *anupana vargaṇā* is used by all living beings for the process of respiration Breathing is an essential activity for sustained life All living beings from *ekendriya* to *panchendriya*, i e , those having a single sense organ of touch to those possessing all the five sense organs, have to breathe to remain alive

According to the scientific view also terrestenal and acquatic animals, insects, and plants have to breathe Of course the respiratory system of fish is different from that of, say, a dog Plants and insects have again quite different types of systems But whatever be the system the stuff that is used in breathing is the element oxygen Some take it from the air and some take it from the water Is oxygen then the stuff belonging to *ānāpāna vargana* of the Jains?

The stuff belonging to *bhaṣa vargana* is used by those who are able to speak According to the Jains, *ekendriya jeeva* or *sthāvaras* are unable to do so but others have the ability to give voice to their feelings, Though not essential for sustaining life, this activity is essential for a purposeful life and to this extent the material in this group is useful for the psychic order of existence

According to the scientific view, the apparatus for producing speech sounds consists of vocal cords, pharynx (wind pipe) larynx (voice box), etc Only those few who are quite high up in the ladder of evolution possess these organs Lower animals can only produce inarticulate sounds from their throats and some others can produce sound not from the throat but by rubbing together other parts of the

body Vibration is an essential condition for producing sound, which is transmitted in the form of sound waves Whether a specific class of matter is necessary for producing voice is not known

We now come to the mental activities The process of thinking and other mental processes according to the Jains require *dravya mana* and *bhāva mana* *Bhāva mana* (psychical mind) is the innate capacity of rational thinking possessed by *samjñin* (developed) souls, while *dravya mana* (physical mind) is the instrument of thinking which the soul makes for itself out of the material belonging to the *manas varganā* which is fit for this purpose Only the *samjñin panchendriya* categories of jeeva have the ability of forming physical mind But the Jains assert that for the process of rational thinking physical mind is as essential as the psychical The stuff covered by this group (*manas varganā*) is very compact Composite bodies of this group are *chatuḥsparśi* and not *astasparśi* meaning they are *agurulaghu* i e devoid of mass

The branch of science that deals with mental phenomena and their classification and analysis is called psychology It seeks to give an account of the way in which the mind works Unlike other sciences (e g chemistry), however, it is concerned more with theories than with facts and still belongs very largely to the province of speculations Though it has, in some respects, attained definite knowledge, it has still to emerge from the phase of speculation with regard to a majority of questions it studies

The fundamental and controversial question of psychology is Is there really a mind[20] to study i e is

20 The word 'mind does not mean the same as the word brain' which is a part of the body and is uncontroversially material

there something of an entirely different nature from the body? Can we not explain the facts of psychology without introducing 'mind'? The intimate relationship and interaction between mind and body is a fact without dispute What is disputable is the adoption of the mental hypothesis which involves the existence of 'mind' i e something which is not of the same order of being as the body We have, thus the two alternatives i) mind as an aspect of body and ii) mind as distinct from body

(i) In the first case the mind consists entirely of physiological instruments such as the sensory nervous systems or receptor nerves which receive the stimuli from outside, the transference machinery to pass on the stimuli to brain, the brain itself and the motor system or effector nerves which govern the movements of the body

In this case the emotions are perceptions of a physiological change in ourselves For example, when we feel the emotion of fear the adrenal glands discharge a certain amount of fluid secretion, which produces changes in the tensions of the muscle and in the blood, resulting in increased rapidity of the heart-beat, etc The awareness of these bodily occurrences constitute the emotion of fear

In the absence of an independent mental instrument the process of thinking is explained as simply subvocal talking,involving as it does the same muscular activities of the larynx as those which occur in talking, although these activities are not carried so far

(ii) In the other alternative viz mind as distinct from body, a unique, distinct and in some sense independent status of mind is contended For contending an independent status of mind it is not necessary to

refute the existence and working of the physiological systems described in the preceding paras All that is necessary is to insist that a living organism is something over and above the physiological apparatus of its body, that mind is an expression of the principle of life and it is distinct from the body and brain Mind, in this case, must be something which is immaterial Wishes, desires, thoughts, aspirations, hopes, acts of will and all such other events which happen in mind are, therefore, immaterial Thoughts, for instance, do not exert force nor do they yield to mass, conversely, mass and material force have no power over thoughts

From the above, it is not difficult to conclude that, in addition to the body and brain the composition of the living organism includes an immaterial element which is called mind that this element although in very close association with the brain is in some sense independent of it Mind so conceived is an active dynamic synthesizing force It is creative that is, it carries on activities which are due to the presence of a living creative impulse to fulfil a purpose

We shall now compare both the above scientific theories of mind with the Jain views regarding *manah* or *manas* The materialist theories of psychology which deny the existence of mind as distinct from body also deny the very existence of consciousness and soul as an independent entity This is entirely in opposition to the Jain views We have already discussed the materialists's concept in the metaphysical section earlier and we shall only add here a doubt which may be raised by the Jains regarding the materialist theory of emotions stated above While accepting the invariable accompaniment of the bodily event and the mental event, a question at issue will

be Does the fear emotion precede and cause the gland excretion or does the gland excretion precede and cause the fear emotion?

The concept of an independent psyche or immaterial mind of the mental hypothesis by the other psychological theories is obviously equivalent to the concept of *bhāva manaḥ* of the Jains *Bhāva manah* as we have stated above, is the innate capacity of jeeva and is therefore immaterial But for the rational mental activities *dravya manah* which is the material counterpart of bhava manah is also essential We have also seen that only highly developed or *samjñin panchendriya*-animals and human beings are capable of forming *dravya manaḥ* out of the material atoms of *manah varganā* and therefore capable of rational mental activities Thus the mental hypothesis to some extent agrees with the Jain view

INTELLECT (BUDDHI)

It will not be out of place to mention here (very briefly of course) an interesting feature of the Jain epistemology viz four buddhis or intellects Intellect is a variety of *Matijñana* i e perceptual cognition There are four categories of *matijñana* viz knowledge i) exclusively due to the sense organs ii) exclusively due to the mind iii) due to the joint activity of the senses and the mind and iv) knowledge independent of both mind and sense organs viz instinctive intuition According to the Jain epistemology, all cognitions are nothing but different states of the soul and as such are only cases of emergence and not origination proper the sense and the mind being auxiliary conditions or instruments only Instinctive intuitions of the vegetable kingdom as well as the underdeveloped animal organisms fall under category iv), Memory, recognition and discursive

thought are cases of *matijñana* under ii) and iii). Sensuous cognition of the five fold sense data - touch, taste, etc , are instances of i)

Buddhi, or intellect falls under category ii) in as much as it is a purely mental perception It is a special gift of nature and independent of the previous education of the perceivers Fourfold intellects are,

1) *Autpātiki buddhi* means immediate comprehension It is defined as the intellect which comprehends the true nature of a previously unknown, complicated problem and successfully solves it It is by a flash of genius that the solution of a difficult and strange problem dawns upon the mind

2) *Vainayiki buddhi* means intellect born of humility and service It is defined as the intellect which is capable of completing a difficult task and is born of humility and faithful service (and not learning)

3) *Karmiki or Karmajā buddhi* means intellect acquired by practice It is defined as intellect which comprehends the truth due to breadth of vision of both the practical and the theoretical sides of actions Such an intellect is the result of extraordinary development of talent through practical experience rather than theoretical learning e g valuation of diamonds and other precious stones

4) *Pāriṇāmikī buddhi* means mature intellect It is defined as the intellect which attains its goal through reasoning, deduction, inference and analogy developed with the maturity of age

It can be easily seen that all these intellects are founded on mental faculties Could flash of genius humility, reasoning, etc , be constituted and produced by physiological changes alone?

Let us return to the material stuff called *manaḥ*

vargaṇā which is fit for the purpose of forming *dravya manaḥ* Admittedly none of the current theories of psychology conceive the necessity of fine material particles (or are they radiations of extremely short wave length?) for the process of thinking and other mental activities

Many scientists, however, see drastic changes on the horizon There would have to be some revolutionary paradgm [21] to explain telepathy, psychokinesis and precognition At least one serious physicist, Gerald Feinberg of Columbia University thinks that psychic transmissions may one day be linked to yet undiscovered elementary particles which may be called mindons or psychons [22] If modern scientific instruments became really successful in detecting such particles they could be equivalent to the group of matter called *manaḥ vargana* by Jains But since, such matter is devoid of mass it is extremely unlikely to be found in its original form

PARYAYA, PARINAMA KRIYA, BHEDA, (FISSION) AND BANDHA (FUSION)

The above terms are used by Jains to show various aspects of the dynamic nature of matter They are meant to indicate that various kinds of energies inhere and are potentially available in the different states of matter and each change of state is accompanied with release or transformation of energy.

Pudgalāstikāya assert the Jains, is an energetic and active substance Various kinds of multifarious activities are attributed to it. First of all there is the

21 *Paradigm* is the word used by Thomas Kuhn for the model of scientific advancement after each major conceptual shift

22 Time (weekly)

artha-paryāya which is the change of state due to its own basic transitory element This type of modification is incessant and continuous and affects the structure of the substance itself. Secondly, there is the *vyañjana-paryāya* which is intermittent and may be the result of interaction between the two substances This type of modification may affect the substance or the inherent qualities of the substance Thirdly, we have *pariṇāma* which means mutation or transformation i e change of qualities like *samsthāna* (shape) etc Then we have different types of motions - simple and complex oscillation, vibration, rotation, revolution and migration, collectively called *kriyā* which describes the dynamic nature of the substance And finally we have *bheda* i e splitting or fission and *bandha* i e union or fusion

PARYAYA

Now according to the atomic theory of modern science atoms of all elements are composed of two parts i) the nucleus which is normally static (with reference to the atom itself) and ii) electrons which are normally revolving around the nucleus The relative motion of electrons is incessant and continuous irrespective of the state of the element being solid, liquid or gaseous It is an inherent characteristic of the structure of all atoms This then is an instance of *artha-paryāya*

Two or more atoms of one element combine together to form molecules and molecules of different elements combine together to form simple and familiar (i e water H_2O and common salt NaCl) or complex and rare (e g phenylpirilliumchloride) compounds i e composite bodies But each compound has its own specific chemical and physical properties under cer-

tain conditions of temperature, pressure, etc Within the body, the molecules themselves are in a state of agitation This motion of molecules of any material substance is known as heat motion or thermal motion, for the simple reason that it is responsible for the phenomenon of heat For, it is molecular motion that produces a certain irritation in the nervous fibres of our sense of touch and produces the sensation that we call heat This thermal motion exists in solid liquid and gaseous states of matter because the amount of energy in every molecule is the same for all substances at a given temperature and the only difference is that while in some case the molecules are able to move around, in other cases they can only vibrate in fixed position This thermal motion appears to be an instance of *vyañjana paryāya*

PARINAMA

Physical properties like extension (volume) mass, density, etc , can be changed by change in temperature and or pressure For instance water is solid (in the form of ice) at temperature O°C or below When heated it becomes liquid and its volume slightly increases At 100°C it boils and changes into steam which has very much larger volume Similarly air (or oxygen) which is gaseous at normal temperature and pressure can be liquified under very high pressures [23] The thermal motion in a solid body is quivering or vibration of molecules If the body is heated the quivering becomes stronger and at the melting point the molecules leave their places and begin to move At still higher temperatures they fly apart in all

23 Temperature of liquid air is 63° absolute or 210° C below zero

directions and the result is gaseous state of matter[24] But the change is in the physical properties only Ice, water and steam are all chemically the same compound H_2O and molecules retain their molecular identities The modification of physical properties and the consequent transformation of one kind of energy into another is perhaps a typical instance of *parināma*.

KRIYA MATTER IS ENERGY

Kriyā is characterised by motion[25] Oscillation and vibrations are inherent attributes of matter and that is why *pudgala* is dynamic Actually all types of motion come under *kriyā*, but motion is only one type of *kriyā* Fission and fusion are also *kriyā* In fact, transformation of energy of any kind is *kriya*, and thus *kriyāvān* means capable of exerting forces and producing energy

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24 If the temperature is raised still farther thermal dissociation takes place and the molecules are broken up into separate atoms For instance molecules of water will be broken up at a temperature over a thousand degress But when the temperature rises to several thousand degrees the matter will be a gaseous mixture of pure elements At still higher temperatures thermal ionization takes place when outer electrons are chipped of from the atoms At a few million degrees (temperature common in the interiors of stars) all electronic shells are completely stripped off and matter becomes a mixture of bare nuclei and free electrons If the temperature goes up to several billion degrees the nuclei themselves break up into protons and neutrons Thus the effect of thermal agitation is to destroy step by step the elaborate architecture of matter into particles rushing around without any apparent law

25 *Parispandana-lakṣaṇā kriyā—Pravachansāra Pradipikā Vriti*, 2-37

Because matter is inherently active, Galileo, Newton and Einstein were able to describe and explain many mysteries of the universe by formulating laws of mechanics Motion of matter evolved a mechanical universe of forces, pressures, tensions, oscillations and waves Two fundamental forces exerted by matter are gravitation and electromagnetism Save for gravitation, nearly all other forces in the material universe—frictional forces, chemical forces which hold atoms together in molecules cohesive forces which bind particles of matter, elastic forces which cause bodies to maintain their shape–are of electromagnetic origin for all these involve the interplay of matter which is composed of electrical particles

To describe the mechanics of dynamic material universe, three parameters are necessary, distance in space time and mass[26] In classical physics the mass of any body is a fixed and unchanging property But Einstein established the relativity of mass, asserting that the mass of a moving body increases with its velocity according to the following equation
when m_o is the mass of a body at rest
m is its mass when moving
v is the velocity of the body
and c is the velocity of light

$$m = \frac{m_o}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$$

It can be readily seen that if v is small the difference between m_o and m is practically zero But when v approaches the value of c then the increase of mass becomes very great reaching infinity when the velocity of the moving body reaches the velocity of light

26 Mass is not heaviness or weight but denotes a fundamental property of matter namely resistance to a change of motion

By further deduction of this principle of relativity of mass, Einstein concluded that energy has mass and disclosed a fundamental truth about physical reality viz., matter and energy are not different elements as pictured by pre-relativity scientists – the former intert, tangible and characterised by a property called mass and the latter active, invisible and without mass He established that mass is simply concentrated energy In other words matter is energy and energy is matter He expresses the inter-changeability of matter and energy by the most famous equation in history $E = mc^2$ It explains how radioactive substances are able to eject particles at enormous velocities for millions of years It reveals the magnitude of energy that slumbers in the nuclei of atoms Translated in concrete values it shows that one kgm of coal if converted entirely into energy would yield 25 billions kilowatt hours of electrical energy Inter-changeability of matter and energy explains the dual role of the electron as a unit of matter and a unit of electricity and the baffling interplay of matter and radiation waves and particles becomes more understandable

The inter-changeability of matter and energy established by modern science is analogus with the Jain concepts of *paryāva, parināma kriyā* etc., being inherent attributes of *pudgalastikāya* The energy of electromagnetic radiations and the particles ejected from radioactive substance are but two different *paryāyas* of the same attribute viz., *kriyāvatva* We shall have occasion to examine the point again while dealing with the nature of *paramāṇu* a little later

Finally we come to the processes of *Bandha* (fusion) and *Bheda* (fission) which are the basis for the nomenclature of matter viz., pudgala These

processes are, according to Jain views (as we have seen)[27] inherent properties of the material universe *Paramāņu*, being indivisible is of course, not fissionable but all other categories of matter undergo both these processes

Modern science, also, (as we have seen)[28] accepts that fission and fusion are essential whenever energy is released, whether it is the chemical energy from coal or the atomic energy from nuclei of uranium or deuterium Again, the process of spontaneous decay of the atoms consisting of emission of alpha particles is not restricted to the so called radio active element, all element heavier than silver (which as we know, occupies the central position in the atomic table) are subject to the process of decay but the process is very very slow Release of enormous atomic energy through the fission process of Uranium nuclei and fusion process of the (heavy) hydrogen nuclei is already described in the previous chapter

IV

ATOMIC THEORY AND PARAMAŅU VADA

HISTORICAL DEVELOPMENT OF ATOMIC THEORY

In the West, Greek philosophy and science were born together at the beginning of the 6th century B C with the first Milesian philosopher Thales As we have seen, the idea of the smallest indivisible ultimate building blocks of matter came in connection with the elaboration of the concepts of being and becoming which characterised the first epoch of Greek philosophy But the atomic theory of matter was propounded much later by Democritus about 420

27 Chapter II pp 73-80

28 Chapter I pp 29-30

B C. The Jain doctrine of *paramāṇu* is undoubtedly much more ancient than the Greek atomists Bhagwāna Pārśvaṇāth (B C 877-777) and Bhagwāna Mahāvira (B C 599-527) propounded the *paramanu* as the ultimate indivisible origin of matter and the Jain canons *Viāhapannatti* (*Bhagvati sūtra*) and *Thānānga Sūt'ı* contain elaborate and detailed discussions on the nature, structure and behaviour of matter in general and *paramānu* in particular

STRUCTURE OF ATOM-ELEMENTARY PARTICLES

Atoms of Democritus were all of the same substance but had different sizes and shapes They were eternally unchanging (Parmenidian), impenetrable and indivisible Atoms themselves had neither colour nor smell nor taste, the sensuousness of the material objects being produced by the motion and arrangement of atoms in space "Sweet and bitter, cold and warm as well as all the colours, all these things exist but in opinion and not in reality, what really exists are unchangeable particles, atoms and their motions in empty space" wrote Democritus

We now know that the objects which were referred to as 'atoms' historically and later during the revival of science in seventeenth century, are not indivisible units of matter According to the modern science the atom of a chemical element is rather a complicated system of smaller units such as protons, neutrons, electrons, etc which are now called elementary particles The number of such elementary particles has now become twenty

It has been established beyond doubt that atoms of various chemical elements are mechanical systems, very much similar to our solar system, with a number

of negatively charged particles (electrons) rotating round the central nucleus which itself is composed of a number of positively charged particles (protons) and electrically neutral particles (neutrons) Protons and neutrons are much heavier than electrons so that the nucleus contain 99 97% of the total atomic mass The number of protons, neutrons, electrons are different in different elements but the atom on the whole is electrically neutral because the total charge of all negatively charged particles equals the total positive charge The simplest and lightest atom is that of hydrogen It is composed of a single proton as the nucleus and a single electron orbitting round it Its diameter is 10^{8} centimeter and mass 1 64 × 10^{23} grammes The distance between the nucleus and the rotating electron is such that the atomic diameter is 100,000 times greater than the diameter of the nucleus In the atom of Uranium there are as many as 92 protons and 146 neutrons in the nucleus and 92 electrons rotate round it in different orbits

PARAMAṆU INDIVISIBLE UNIT OF MATTER

Paramāṇu, as defined by Jain philosophy, on the other hand is a truly indivisible fundamental unit of matter and therefore has no components It is not composed of many particles and is dimensionless Like a true geometrical point, it has no length, no breadth, and no thickness Its centre is identical with its ends Thus it has no extension and occupies only a single space point It has no shape and it has no mass It is, however, not an abstract piece of matter deprived of the qualities of colour, smell etc , like the atom of Democritus It has a real objective existence and does possess colour, smell, etc Inspite of this, a *paramāṇu* by itself is not perceivable by sense organs

and can only be cognised by inference through the effects of collective actions or by direct experience of a transcendental knowledge This apparent paradox of being in possession of sensuous qualities like colour, etc, on the one hand and yet not being an object of sensuous cognition on the other is beautifully resolved by the explanation of quantum phenomena and the principle of uncertainty Quantum physicists do not concern themselves with the properties of an individual electron because it is impossible to ascertain them On the other hand electron behaviour can be accurately defined when dealt with collectively in great numbers The individual electron is indeterminate and the indeterminacy is not a symptom of immature science but an ultimate barrier of nature For by the very act of observing its position its velocity is changed and conversely the more accurately its velocity is determined, the more indefinite its position becomes Thus, it is impossible to determine the position and velocity of an electron at the same time

A *paramānu* in its unattached free state is as real as a *paramānu* within material aggregate and the qualities of colour, etc are as much real in a free *paramānu* as they are in an attached one A free *paramānu* when captured by an aggregate, loses its free state and is changed to become a component of the aggregate Similarly its qualities also undergo changes of intensity Thus the same *paramānu* (as substance) which possessed one unit blackness can change to become infinitely black

Two or more *paramānus* mutually combine together to produce material compositions and the entire material world is composed of *paramānus* The aggregates composed by *paramānus* have shape and

extension in space although the *paramāṇu* itself is devoid of shape and has no extension By this it is meant that a single free *paramāṇu* does not occupy two or more space points The elementary particles of modern science are presumed to be spherical in shape Their diameters though very small are measurable and therefore their extension in space cover innumerable space points This, according to Jains, means that the elementary particles of science viz, protons, electrons, etc, are not indivisible but composed of innumerable *paramāṇus* Thus an electron is infinitely more gross than a *paramāṇu*

QUALITIES AND ATTRIBUTES

Paramāṇu is eternal *(nitya)* indestructible *(ānaśwar)*, non-transmutable *(avasthita)*, and indivisible *(avibhājya)* A *paramāṇu* cannot be split or scattered or fissioned nor can it be composed or created by fusion

When it was said that the word *pudgala* is derived from the properties of fission and fusion it was meant that the formation of material aggregates by the natural association of a number of *paramāṇus* is fusion and the splitting of aggregates into its components is fission *Paramāṇu* itself though subject to mutation, is unfissionable and maintains its individual existence permanently

The atom of a chemical element as well as its constituents, the elementary particles electrons protons, etc, are on the other hand, fissionable and fusionable radioactive elements emit alpha and other particles and lose energy by radiation, protons and neutrons are mutually transformable by losing or acquiring a positive charge Other elementary particles get transformed into electromagnetic waves

and radiation Thus according to Jain view, the elementary particles are not fundamental units of matter but masses composed of innumerable (or infinite) *paramāṇus*

The totality of *paramānus* in universe cannot be expressed by numbers It is infinite Since a *paramāṇu* can neither be destroyed nor created, totality of *paramānus* in the universe is unchangeable This is comparable to the law of conservation of matter and energy which states that the total amount of matter and energy in the universe is constant and unchangeable Modification of this law is mooted as a result of some very recent observations and we shall revert to this point in the succeeding paragraphs.

Earlier, we had seen that colour, taste, smell and touch, etc , are intrinsic qualities of all material objects A *paramānu* being the fundamental unit of matter must also possess each of these qualities Thus a *paramānu* will possess the following five qualities

One (either good or bad) smell

One of the five elementary colours

One of the five elementary tastes and

Two of the four elementary *sparśa* viz either hot or cold and dry or unctuous

Thus in respect to the quality of *sparśa* alone there are four types of *paramāṇus*

1 Unctuous-cold
2 Unctuous-hot
3 Dry-cold
4 Dry-hot

And with different combination of colour etc we have 5×2×5×4= 200 types of *paramāṇus* Now since the intensities of colour, taste, etc vary from minimum one unit to maximum infinite units, there will be infinite varieties of paramāṇus with different

intensities and combinations of colour, taste, etc e g in respect to colour, there will be *paramāṇus* with one unit blackness, two units of blackness upto infinite units of blackness The intensities of the qualities of any given *paramāṇu* is subject to increase or decrease by its mutations into different states of association and dissociation within aggregates

Now, we should be quite clear about the meaning of the statement 'a *paramāṇu* possesses one colour' We have already said that an individual *paramāṇu* by itself is never an object of sensuous cognition and we have also said that *paramāṇus* are cognised by their collective or group behaviour only Then what do we mean by saying that this individual *paramāṇu* is 'red' What we mean here is that a red *paramāṇu* will always vibrate with a frequency corresponding to the red colour The colour of a composite body would thus be determined by the resultant of the frequencies of its components

Comparing these intrinsic qualities of *paramāṇus* with those of elementary particles protons neutrons etc we find that mass and an electrical charge(+ve or-ve) are inherent qualities of the latter if we equate the dryness and unctuousness with positive and negative electric charges and heaviness and lightness with mass, then a *paramāṇu* has no mass but possesses an electric charge Fine *chatuhsparsi* compositions of some *vargaṇās* also have no mass The quality of mass is inherent only in *aṣṭasparśi vargaṇās* of *pudgala* viz., *audārika*, *vaikriya āhāraka* and *taijas* The existence of matter in a state of masslessness may be unacceptable to the modern science But some recent observations point to the possibility of such an existence

MECHANICS AND MATHEMATICS OF *PARAMANU*

Berkeley attributed the functional harmony of nature to God Modern physicists (who do not like to take recourse to God) prefer to emphasise that nature operates on mathematical principles In 1900 Max Planck put forth his Quantum theory, dealing with the fundamental units of matter and energy It provides equations that define with great accuracy the laws governing the propagation of radiant energy The extraordinary feature of this theory was that it rested on the assumption that radiant energy is emitted not in an unbroken stream but in discontinuous bits or portions which Planck termed 'quanta'

On purely theoretical grounds he concluded that each quantum carries an amount of energy given by the equation $E = h\nu$ where ν is the frequency of radiation and h is Planck s constant[29] a small but inexorable number which has since proved to be one of the most fundamental constant in nature All forms of radiant energy-light heat X-rays-actually travel through space in separate and discontinuous quanta and the amount of emitted energy divided by the frequency is always equal to h Thus sensation of colour arise from the bombardment of our optic nerves by light quanta which differ from each other just as the frequency varies in the equation $E = h\nu$

Another universal constant is the velocity of light which was accurately determined in 1849 to be 186 284 miles per second[30] The velocity of light is unaffected by the motion of earth sun moon, star or

29 The latest value of Planck s constant is determined to be $6\,625\,17 \times 10^{-34}$ joule-second

30 The latest corrected value is determined to be $2\,997925 \times 10^{8}$ meters per second in vacuum

other system moving anywhere in the universe i e it is constant throughout the universeand is unaffected either by the motion of its source or the motion of the receiver We are already familiar with Einstein's equation giving the increase in mass with velocity of a moving body where this constant is used

$$m = \frac{m_0}{\sqrt{1 - \frac{V^2}{c^2}}}$$

When m_0 is mass of a stationary object or rest mass
m is its mass when in motion
V is its velocity
C is the velocity of light

From the above equation we can see that as V increases the mass also increases and when V is equal to C mass will be infinity We had come across an instance of increase in mass while discussing the production of high energy particles by proton-synchroton machine [31] There we had learnt that as the speed of accelerated protons approached that of light, its mass increased rapidly When protons reached a speed which corresponded to about 99% of the speed of light, the rest mass of the particles was found to have increased thirty times From this it is clear that the speed of a particle of matter is always lower than the speed of light and other radiations

Mechenics and mathematics of *paramānu* as discussed in the *Bhagvati Sūtra*[32] shows that the activities and movements of *paramānu* are both complex and unpredictable It is particularly emphasised that there is an element of periodicity in the activities of the *paramānu* It is sometimes at rest and sometimes in motion after remaining at rest for a certain period of time, it must commence motion and

31 See chapter I p 38
32 See chapter II pp 91 92

certain period of motion The maximum and minimum periods of rest and motion are definite Such alternate periods of rest and motion to a certain extent agrees with the Max Planck's quantum physics the frequency of vibration of the *paramāṇu* being determined by its 'colour'

Difference in the kinds of motions of a *paramāṇu* are, shown by different terms such as *eyati, veyati*, etc, what exactly each term means is not easily comprehensible Simple oscillation, vibration, complex vibration and linear motion are some of the kinds of motion Rotation is ruled out because in a point there cannot be an axis to rotate around Revolutionary motion or stationary-wave in a space point are possibilities It probably means linear motion accompanied with vibratory motion or state of vibration with changing frequency

Linear motion of a *paramānu* means moving about from one space point to another This motion or change of motion may take place under the influence of outside forces exerted by another *paramāṇu* or an aggregate or it may be spontaneous Jeeva, however, can never exert any influence on the motion of a *paramāṇu*

While discussing the movements of a *paramānu* as described in the *Bhagvatī Sutra*, we had mentioned that while in some respects movements *(gati)* of a *paramānu* follow definite rules, in many other respects they are indeterminate and uncertain Now principle of uncertainty is also a half century old scientific dictum enunciated by an eminent physicist Werner Heisenberg in 1927 At that time quantum physics had defined with great accuracy the mathematical relationships governing the basic units of radiation and matter But it had failed to reveal the

true nature of either Eminent physicists, Werner Heisenberg amongst them, declared that there is an element of caprice in atomic behaviour which stems from the very nature of matter and cannot be blamed on man's coarse-grained implements They added further, that there is an element of indeterminacy about the events of the atomic universe which cannot be dispelled by the refinement of measurements and hence it is futile to hope that invention of more delicate tools may enable us to penetrate further into the microcosm A physicist can give an accurate account of electron behaviour so long as he is dealing with great numbers of them collectively but he cannot locate an individual electron in space in respect of its position and velocity The Principle of Uncertainty asserts that it is impossible to determine the position and velocity of an individual electron at the same time because by the very act of observing its position, its velocity is changed and conversely, the more accurately its velocity is determined, the more indefinite its position becomes

The motion of *paramāṇu* in space is subject to the following rules also –

Spontaneous *motion* is in '*anusreṇi*' which literally means straight line but which really means the minimum distance between the two space points If the geometry of the *Lokākāśa* is Euclidian then it will be a straight line but if this geometry is non-Euclidian then the minimum distance may be a curved line Since the space of *Lokākāsa* is accepted to close upon itself, the latter alternative is a greater possibility According to the rules and propagation of radiation in space light also travels in a straight line (if free from the influence of external forces) But the modern cosmology accepts the geometry of the space

as non-Euclidian i e it closes upon itself Motion of a *paramāṇu* under the influence of external forces may also be in *viśreṇi* i e curved line But if the time of motion is one time point only, the motion is always in *anusreṇi*

The minimum velocity of a *paramāṇu* is one space point in one *samaya* [33] (time point) while the

[33] Samaya and Loka are two terms unique to the Jain Philosophy Samaya is the infinitesimal indivisible unit of time A comparatively larger unit of time which is measurable is called AVALIKA and is equal to 1.7×10^{-4} seconds One āvalikā covers Jaganya-Yukta-Asamkhyata' samayas This number is impossible to be expressed in numerical figures but it can be shown to have definite measurable value and its lower limit can be calculated Jain mathematics express this number as greater than

$$x \text{ where } x = y^{y^{y^{y^{\cdot^{\cdot^{\cdot}}}}}} \; 10^{134} \text{ times} \quad \text{and } y = 10^{10^{10^{143}}}$$

A comparison of this Jain view with the most modern scientific attempts and various methods for the accurate measurement of time might be interesting

SECOND, the present unit of time was earlier defined with reference to the time taken for the rotation of earth and in 1954 the International Committee of Weights & Measures standardised the second as 1/31,556,925 975 of the tropical year 1900 The second thus defined was known to vary to the extent of 1 part in 10^8 and did not entirely satisfy the present scientific quest Subsequently other considerations compelled them to switch over to a different form of time standard which ultimately led to the advent of atomic standards In 1964 the above Committee adopted the transition between two specified energy levels of cessium 133 for the purpose of defining the basic unit of time Cessium beam oscillators were developed and in 1967 the Committee defined the unit of time as follows

maximum velocity is the entire length of the universe in one *samaya* When in motion, the minimum distance travelled by a *paramāṇu* in one *samaya* (indivisible unit of time or time point) is one space point i e the distance between two adjacent space points And the maximum distance travelled by a *paramāṇu* in one *samaya* is between the extremities of the loka [34]

How is this Jain view compatible with the Einsteinian equation of the increase of mass and the inference that nothing can travel faster than the speed of light the theoretical speed limit of the universe?

If we accept the value $m_0=0$ i e a *paramāṇu* has no mass then the equation of the increase in mass

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the second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the fundamental state of cessium 133 atom '

Various methods of standardisation of time in terms of the frequency of hydrogen maser are also available but the order of accuracy does not seem to exceed that of the former cases

Recently a new and simple method for standardisation of time is suggested by M/s S K Mukherjee and A Choudhury of Jadavpur University It is based on the velocity of electrons under the action of crossed electric and magnetic fields It has been shown that under certain conditions the electron will move in a rectilinear path at a constant velocity and the time taken to traverse a distance of 1 cm is 0 533 168 432 $\times 10^{-9}$ second This suggestion leads to the conception of a unit of time very much smaller than the second It will be .533 168 432 $\times 10^{-9}$ second In other words one second will contain 1 87557997 $\times 10^{9}$ and one *āvalika* will contain 300 000 (app) of these units

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34 The maximum distance between two extremities of *Loka* is 14 *Rajjus* where a Rajju covers *asamkhyāt yojanas* and can be roughly expressed as R(Rajju) $10^{10^{196}}$ light-years Thus the maximum velocity of a *paramāṇu* is not less than N light-years per second where $N = X^{y} \times R$

with velocity becomes inapplicable Now we have seen that, 'mass' is not an intrinsic quality of *paramāṇu* Mass, according to the Jain view is one of the four pairs of *sparśas* which are i) hot-cold ii) unctuous–dry iii) heavy–light and iv) hard–soft *Paramāṇus* (and even material aggregates of some *vargaṇās* though composed of innumerable *paramāṇus*) are *chatuhsparsi* i e are *agurulaghu* (literally neither heavy nor light) which means they are massless It would be interesting to mention here that some scientists like Gerald Feinberg think that there are particles (such as tachyon) which always travel faster than the speed of light [35]

Can the existence of massless matter and speed faster than that of light be definitively refuted by modern science especially in view of the proliferation of weird subatomic particles (more than 15) discovered by it? "The new generation of qunatum physicists not accepting the atom as simply a miniature solar system in which negatively charged electrons circle the positively charged nucleus have found the electrons keep jumping from one orbit into another without passing through the intervening space They have also succeeded in producing such ghostlike particles as the neutrino which has no

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35 'There are particles which at rest would have no mass at all–a rest mass of zero light is made up of 'photons' particles that have a proper mass of zero Other particles such as 'neutrinos' and 'gravitons' also have a proper mass of zero Particles with zero mass means that their inertia is zero and they can be accelerated to any velocity upto infinite In 1967, physicist Gerald Feinberg in discussing these faster–than–light particles called them tachyons from a Greek word meaning speed '(–Isaac Asimov 'SPAN magazine 16th July 1973)

mass, no electrical charge and can hurtle with ease through the entire earth "[36, 37]

SYNTHESIS OF *PARAMANUS* INTO COMPOSITE BODIES

We had discussed the nature of various forces which

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36 'The Roots of Coincidence' by Arthur Koestler

37 Units of measurement

There are three fundamental units of modern scientific measurement They are units of length mass and time The unit of length metre was defined earlier as one ten-millionth part of a quarter meridian In 1967 this was replaced by the wave-length of orange-red radiation of Krypton[86] The present valid definition of the unit of length is ' 1 650 763 73 wave lengths of orange-red radiation of Krypton[86] in vacuum Initially the unit of mass gramme' was considered the mass of a cubic centimetre of water at its maximum density Later on in MIS system this was changed to kilogram i e the mass of a cubic decimeter of water But this suffered from the inherent uncertainty associated with the measurement of volume and temperature In 1960 kilogram was independently defined as the mass of a platinum-iridium cylinder which is preserver at International Bureau of Weights & Measures at Sevres Paris

This definition of mass has been considered in a mode rather than a rule So the defining of both mass and length in terms of a certain wave-length of light may provide a coherent means The wave and particles nature of light inspires M/s S K Mukherjee and A Choudhury to conceive the mass equivalence of the particle associated with the orange-red radiation of Krypton[86] and a suggestion is put forward by them to define kilogram in terms of the mass of a particle whose De Broglie wave-length is already taken for standardisation of length Thus the kilogram can be considered in terms of the number of particles associated with the radiation in order to follow the international convention of standards A precise estimation of the number of particles assumes the value 2 741 18798 $\times 10^{35}$

We have already discussed the unit of time a little earlier

are responsible for the fission and fusion of material objects First, there are forces which bind together the atoms of different elements into complex molecules of innumerable chemical compounds, and are the interaction of electronic shells of the component atoms Then there is repulsive electrical force in the nucleus, known as the coulomb force And finally there are the cohesive forces which are many times greater and which act as the cosmic cement preventing the breaking up of the nucleus of an atom under the action of coulomb force The qualities *snigdha* and *ruksha sparśa,* according to the Jain view, play the most important role in the synthesis of different *paramānus* for the formation of atoms, molecules and small and large objects of matter The intensity of these two primary qualities varies from a single unit to infinite units in different *paramānus*-that is at a given moment some *paramānus*-have a single unit of unctuousness, some are with two units some with three and so on upto infinity At the same time there will be some *paramānus* with a single unit of dryness, some with two units and so on upto infinity A summary of the rules in respect of the synthesis of different *paramānus* is as under

1 Synthesis of *paramānus* having single units of dryness or unctuousness is not possible either with one another or with *paramānus* of higher intensities

2 Synthesis of *paramānus* having two or more units of dryness is possible with other dry *paramānus* provided there is a difference of two or more units between them Similarly mutual synthesis of unctuous *paramānus* is possible only if the difference of their intensities is two or more units

3 Synthesis of *paramāṇus* having two or more units of dryness with all unctuous *paramānus* (except those with a single unit) is possible [38]

The following points of similarity between the views of Jains and the modern science emerge from the above

The dryness and unctuousness may in some respect be equated with the + ve and -ve electric charges of the elementary particles The interaction of the electronic shells of neighbouring atoms in a molecule, which creates the chemical bond necessary to keep them united, is then equivalent to the interaction and union between *paramānus* of same type of *sparśa* i e *sparśa* equivalent to -ve charge The first completed shell consists of two electrons The minimum difference between the uniting *paramānus* of similar *sparsa* is two units The quality of mass does not play any significant role in the process of synthesis

38 The following table shows the permissible (or otherwise) combination of *paramāṇus* with different intensities of dryness and unctuousness

Intensity of Sparsha	Dry (-) with Dry (-) Unctuous (+) with Unctuous (+)	Dry (-) with Unctuous (+)
Unit + Unit	No	No
Unit + 2 Units	No	No
Unit + 3 Units	No	No
Unit + 4 or more units	No	No
X units + X units	No	Yes
X units + (X+1) units	No	Yes
X units + (X+2) units	Yes	Yes
X units + X+3 or more units	Yes	Yes

X is greater than one

On the other hand the following questions arise

Is the unit of *snigdha sparsa* (or *rukṣa*) equivalent to the unit +ve (or -ve) charge?

DENSITY OF MATTER

We had seen that the matter in the universe is more dense in some places than in others Thus in the nucleus of an atom the matter is so dense that a paise would weigh 600 million tons if its atoms were as tightly packed as the particles in the nucleus

A *paramāṇu* as we have said is the ultimate indivisible unit of matter It has no extension and therefore is equivalent to a point Logically, therefore, a *paramāṇu* at rest will occupy one space point How much space will be occupied by *skandhas* which are composed of two, three, four, million, billion, or asamkhyata (innumerable) *paramānus*? The maximum number of space points occupied by a skandha is equal to the number of its *paramāṇus* A *skandha with infinite paramānus* will occupy *asamkhyāta* points When more tightly packed however, a composition would extend to space points less than the number of *paramāṇus* And in the extreme case a composition with infinite *paramānus* may occupy only a single space point

We have said that not a single *paramāṇu* can be created or destroyed i e whatever be the total number of *paramānus* in the universe is a constant, what is this number? It is inexpressible in numerical figures It is infinite times the total number of *Jeevas* which is itself infinite The number of *skandhas* (composition) is also infinite

DUALITY OF PARAMANU

At this stage we may raise some fundamental que-

stions, what is the true nature of *paramāṇu*? Is it a particle or a wave? Is it matter or energy (radiation)? Does it have an electromagnetic field or a gravitational field?

In the final section of the previous chapter we had discussed the *"apratighāti"* property of *paramāṇu* where it was stated that a *paramāṇu* is capable of penetrating and passing through any type of obstruction Now, we know that the penetrating power of an electromagnetic radiation is inversely proportional to its wave-length i e shorter the wave-length of the radiation, higher is its penetrating power From the stand point of physics the only difference between the long radio waves (between 10^8 & 10^7 cm) at one end of the electromagnetic spectrum visible light (between 10^{-4} & 10^{-5} (cm) in the middle and cosmic rays (10^{-11} to 10^{-12} cm) at the other end lies in their wave length Visible light can pass through only a few substances like glass The wave length of red light is 00007 cm and that of violet light 00004 cm X-rays which are shorter (10^{-6} to 10^{-8} cm) than visible light can pass through many more substances which are opaque to light waves Shorter than x-rays are gamma rays (10^{-8} to 10^{-10} cm) of radium etc which can penetrate several feet of cement concrete The shortest known electromagnetic radiations are cosmic rays with wave lengths of 10^{-10} to 10^{-13} which can penetrate even more Thus shorter the wavelengths, higher is the penetrating power of a radiation Now, if *paramāṇu* is accepted to possess infinitely more penetrating power than the gamma rays or even cosmic rays, it must be regarded as radiant energy with an infinitesimally small wavelength This aspect, then, compels us to visualise *paramāṇu* as radiant energy

On the other hand, it is more rational to regard *Paramāṇu*, the ultimate unit of matter to be an individual particle The properties attributed to *paramānu* compels us to visualise it as a particle, or a corpuscle rather than a wave For instance, it has been stated that *paramāṇu* is sometimes at rest and sometimes in motion What is the meaning of 'at rest' here? Does it mean a stationary wave in space or a stationary particle? Thus we cannot decide whether *paramānu* is a particle or a wave It sometimes behaves as a particle and sometimes as a wave It has therefore a dual character

A remarkably strange and deep duality pervaded the physical universe of pre-Einstein age One aspect of this dualism was the question - Is matter 'waves' or is it 'particles'? Light for example is classically regarded as electromagnetic waves and the difference in the colours is explained by the difference in wave-lengths and electron commonly was a particle with a negative electric charge On the other hand, certain peculiar effects of light could be explained only by assuming that it is composed of individual particles or grains of energy called photons and it has been proved by experiments that electrons actually do exhibit wave characteristics Not only electrons but whole atoms and even molecules produce wave patterns when diffracted by a crystal surface Another aspect of the strange dualism of the physical order of existence is the concept of two elements, matter and energy The former inert, tangible and massive and the latter active, invisible and without mass The two fundamental forces exerted by matter—gravitation and electromagnetism—are yet another aspect of the deep duality of matter Almost all the phenomena of

physical universe are produced by these two primordial forces While the gravitational forces dominate such phenomena of macrocosm as the motion of planets and stars, the electromagnetic forces are predominant in the microcosm of the heart of atoms

Today Einstein's Unified Field Theory has unified the physical laws governing the two primordial forces The famous equation $E=mc^2$ has shown that matter and energy are mutually transformable, the distinction being simply one of temporary state The paradox presented by the waves of atoms and particles of light has been resolved by a new mathematical apparatus that permitted accurate description of quantum phenomena either in terms of waves or in terms of particles as one wished Today the whole complex of the physical universe is almost resolved into homogenous fabric in which matter and energy are indistinguishable, the abyss between macrocosm and microcosmos is almost bridged, and all forms of motions tend to become simply changes in the structure and concentration of the single primordial field

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ATOMIC No	Name	SYMBOL	Atomic Wt	GROUP or	FAMILY	Number of Electrons in each shell				
1	Hydrogen	H	1 008		1					Unique
2	Helium	He	4 0026	VIIIA	2					Inert Gas
3	Lithium	Li	6 939	IA	2	1				Alkali & Alkaline
4	Beryllium	Be	9 0122	IIA	2	2				Earth Metals.
5	Boron	B	10 811	IIIA	2	3				Boron and
6	Carbon	C	12 011	IVA	2	4				Carbon families
7	Nitrogen	N	14 007	VA	2	5				Nitrogen and
8	Oxygen	O	15 999	VIA	2	6				Oxygen Families
9	Fluorine	F	18.998	VIIA	2	7				Halogens
10	Neon	Ne	20 183	VIIIA	2	8				Inert gas
11	Sodium	Na	22 990	IA	2	8	1			A & A E M
12	Magnesium	Mg	24 312	IIA	2	8	2			
13	Aluminium	Al	26 982	IIIA	2	8	3			B& C Family
14	Silicon	Si	28 086	IVA	2	8	4			B& C Family
15	Phosphorus	P	30 974	VA	2	8	5			N & O Family
16	Sulphur	S	32 064	VIA	2	8	6			N & O Family
17	Chlorine	Cl	35 453	VIIA	2	8	7			Halogen
18	Argon	Ar	39 948	VIIIA	2	8	8			Inert gas
19	Potassium	K	39 102	IA	2	8	8	1		A & A EM
20	Calcium	Ca	40 08	IIA	2	8	8	2		A & A EM
21	Scandium	Sc	44 956	IIIB	2	8	9	2		
22	Titanium	Ti	47 90	IVB	2	8	10	2		First
23	Vanadium	V	50 942	VB	2	8	11	2		Transition
24	Chromium	Cr	51 996	VIB	2	8	13	1		Metals
25	Manganese	Mn	54 938	VIIB	2	8	13	2		
26	(Ferrum)									
	Iron	Fe	55 847	VIIIB	2	8	14	2		The Triads
27	Cobalt	Co	58 933	VIIIB	2	8	15	2		Second Transition
28	Nickel	Ni	58 71	VIIIB	2	8	16	2		Metals
29	Copper	Cu	63.54	IB	2	8	18	1		Third Transition
			58 74							
30	Zinc	Zn	65 37	IIB	2	8	18	2		Metals
			65.54							
31	Gallium	Ga	69 72	IIIA	2	8	18	3		B & C Fam
32	Germanium	Ge	72 59	IVA	2	8	18	4		B & C Fam
33	Arsenic	As	74 922	VA	2	8	18	5		N & O Fam
34	Selenium	Se	78 96	VIA	2	8	18	6		N & O Fam.
35	Bromine	Br	79 909	VIIA	2	8	18	7		Halogen
36	Krypton	Kr	83 80	VIIIA	2	8	18	8		Inert gas
37	Rubidium	Rb	85 47	IA	2	8	18	8	1	A & AEM
38	Strontium	Sr	87.62	IIA	2	8	18	8	2	
39	Yttrium	Y	88 905	IIIB	2	8	18	9	2	
40	Zirconium	Zr	91.22	IVB	2	8	18	10	2	First

41	Niobium	Nb	92 906	VB	2	8	18	12	1		Transition
42	Molybdenum	Mo	95.94	VIB	2	8	18	13	1		Metals
43	Technetium	Tc	99	VIIB	2	8	18	13	2		
44	Ruthenium	Ru	101.07	VIIIB	2	8	18	15	1		Triads Second
45	Rhodium	Rh	102 91	VIIIB	2	8	18	16	1		Transition
46	Palladium	Pd	106 4	VIIIB	2	8	18	18			Metals
47	(Argentum)										
	Silver	Ag	107 87	IB	2	8	18	18	1		Third Transition
48	Cadmium	Cd	112 40	IIB	2	8	18	18	2		Metals
49	Indium	In	114 82	IIIA	2	8	18	18	3		B & C Fam
50	(Stannum)										
	Tin	Sn	118 69	IVA	2	8	18	18	4		B & C Fam
51	Antimony	Sb	121 75	VA	2	8	18	18	5		N & O Fam
52	Tellurium	Te	127 60	VIA	2	8	18	18	6		&
53	Iodine	I	126 90	VIIA	2	8	18	18	7		Halogen
54	Xenon	Xe	131.30	VIIIA	2	8	18	18	8		Inert gas
55	Cesium	Cs	132 91	IA	2	8	18	18	8	1	A & AEM
56	Barium	Ba	137.34	IIA	2	8	18	18	8	2	
57	Lanthanum	La	138 91	IIIB	2	8	18	18	9	2	
58	Cerium	Ce	140 12		2	8	18	19	9	2	
59	Praseodymium	Pr	140 91		2	8	18	21	8	2	57 to 71
60	Neodymium	Nd	144.24		2	8	18	22	8	2	Rare earths.
61	Promethium	Pm	147		2	8	18	23	8	2	
62	Samarium	Sm	150 35		2	8	18	24	8	2	
63	Europium	Eu	151 96		2	8	18	25	8	2	
64	Gadolinium	Gd	157.25		2	8	18	25	9	2	
65	Terbium	Tb	158 92		2	8	18	26	9	2	
66	Dysprosium	Dy	162 50		2	8	18	28	8	2	
67	Holmium	Ho	164 93		2	8	18	29	8	2	
68	Erbium	Er	167 26		2	8	18	30	8	2	
69	Thulium	Tm	168 93		2	8	18	31	8	2	
70	Ytterbium	Yb	173 04		2	8	18	32	8	2	
71	Lutetium	Lu	174 97		2	8	18	32	9	2	
72	Hafnium	Hf	178 49	IVB	2	8	18	32	10	2	First
73	Tantalum	Ta	180 95	VB	2	8	18	32	11	2	Transition
74	(Wolfram)										
	Tungsten	W	183 85	VIB	2	8	18	32	12	2	Metals
75	Rhenium	Re	186 2	VIIB	2	8	18	32	13	2	
76	Osmium	Os	190 2	VIIIB	2	8	18	32	14	2	The Triads
77	Iridium	Ir	192.2	VIIIB	2	8	18	32	15	2	Second
78	Platinum	Pt	195 09	VIIIB	2	8	18	32	17	1	Tr Metals
79	(Aurum)										
	Gold	Au	196 97	IB	2	8	18	32	18	1	Third Tr
80	(Hydragyrum)										
	Mercury	Hg	200.59	IIB	2	8	18	32	18	2	Metals
81	Thallium	Tl	204.37	IIIA	2	8	18	32	18	3	B & C Fam
82	(Plumbum)										
	Lead	Pb	207 19	IVA	2	8	18	32	18	4	
83	Bismuth	Bi	208 98	VA	2	8	18	32	18	5	N & O
84	Polonium	Po	210	VIA	2	8	18	32	18	6	Family
85	Astatine	At	210	VIIA	2	8	18	32	18	7	Halogen

86	Radon	Rn	222	VIIIA	2	8	18	32	18	8		Inert gas
87	Francium	Fr	223	IA	2	8	18	32	18	8		IA & A M
88	Radium	Ra	226	IIA	2	8	18	32	18	8		2A & A.M
89	Actinium	Ac	227		2	8	18	32	18	9	2	
90	Thorium	Th	232 04		2	8	18	32	18	10	2	
91	Protactinium	Pr	231		2	8	18	32	20	9	2	89—103
92	Uranium	U	238.03		2	8	18	32	21	9	2	Actinide metals
93	Neptunium	Np	237		2	8	18	32	22	9	2	
94	Plutonium	Pu	242		2	8	18	32	24	8	2	
95	Americium	Am	243		2	8	18	32	25	8	2	
96	Curium	Cm	247		2	8	18	32	25	9	2	
97	Berkelium	Bk	247		2	8	18	32	27	8	2	93 to 103
98	Californium	Cf	249		2	8	18	32	28	8	2	
99	Einsteinium	Es	254		2	8	18	32	29	8	2	Man made
100	Fermium	Fm	253		2	8	18	32	30	8	2	elements
101	Mendelevium	Md	256		2	8	18	32	31	8	2	
102	Nobelium	No	254		2	8	18	32	32	8	2	
103	Lawrencium	Lw	257		2	8	18	32	32	9	2	